JPRS 71569

28 July 1978

USSR

TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY

BIOMEDICAL AND BEHAVIORAL SCIENCES

No. 39

U. S. JOINT PUBLICATIONS RESEARCH SERVICE

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BIBLIOGRAPHIC DATA SHEET	1. Report No. JPRS 71569	2.	3. Recipient's Accession No.
4. Title and Subtitle TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY BIOMEDICAL AND BEHAVIORAL SCIENCES, No. 39			5. Report Date 28 July 1978 6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Joint Publications Research Service 1000 North Glebe Road Arlington, Virginia 22201			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address As above			13. Type of Report & Period Covered 14.

15. Supplementary Notes

16. Abstracts

The report contains information on aerospace medicine, agrotechnology, bionics and bioacoustics, biochemistry, biophysics, environmental and ecological problems, food technology, microbiology, epidemiology and immunology, marine biology, military medicine, physiology, public health, toxicology, radiobiology, veterinary medicine, behavioral science, human engineering, psychology, psychiatry and related fields, and scientists and scientific organizations in biomedical fields.

17. Key Words and Document Analysis. 17a. Descriptors

USSR	Medicine
Aerospace Medicine	Microbiology
Agrotechnology	Physiology
Biology	Psychology/Psychiatry
Botany	Public Health
Epidemiology/Immunology	Radiobiology
Human Engineering	Toxicology
Marine Biology	Veterinary Medicine

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group 2, 5E, 5J, 6, 8A

18. Availability Statement Unlimited Availability Sold by NTIS Springfield, Virginia 22151	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 100
	20. Security Class (This Page) UNCLASSIFIED	22. Price PC A05

JPRS 71569

28 July 1978

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CONTENTS PAGE

CONTENTS (Continued) Page

UDC 634.0.863.5.002.2

PRODUCTION OF FODDER YEASTS

Moscow PROIZVODSTVO KORMOVYKH DROZHZHEY in Russian 1970 signed to press 24 Jun 70 pp 4-25, 54-56, 84-87, 168-172, 236-237

[Portions of Chapters 1-6 from the book "Proizvodstvo kormovykh drozhzhey" by A. A. Andreyev and L. I. Bryzgalov, Izdatel'stvo "Lesnaya promyshlennost," 3000 copies, 296 pages]

[Text] Chapter 1. General Information About the Production of Fodder Yeasts

Of enormous importance to the creation of the material and technological base of communism is a sharp increase in the production of products of animal husbandry. Necessary for that is a reliable fodder base. This task is solved in many ways. However, none of them can satisfy the needs of animal or poultry raising if the fodder does not contain proteins and vitamins in sufficient quantities. Even such valuable fodder as corn and the sugar beet, which provide a maximum quantity of feed units per hectare of land, rich in carbohydrates but not containing a sufficient quantity of nitrogenous substances, can be effectively used only when full-valued protein, vitamins and minerals are added.

One kg of winter rye straw contains a total of 4 g of digestible protein, of fodder beet 3 g, of oat husks 21 g, of very good meadow hay 50 g, of corn silage 6 g, and of oat grains 77 g of digestible protein [1].

The need for digestible protein is 500-800 g/day for a non-milch cow, up to 1500 g for a milch cow and up to 500 g for a young sow.

The deficit of fodder protein that occurs in our country is noted in all countries of the world. The deficit is covered by increasing the production of plant protein contained in agricultural fodder crops: grain, lucerne, hay, etc, increase of the output of fish and meat meal, dry milk products and skim milk, and the use of carbamide (urea) and simpler ammonium compounds for ruminant animals as partial substitutes for protein. In recent years more and more importance has been acquired in the fodder rations of animals by fodder yeasts obtained at hydrolysis and pulp enterprises during the use of carbohydrates contained in the hydrolyzates and sulfite liquors for that

purpose. Those fodder yeasts are a biologically full-valued fodder, a source of protein, vitamins and minerals. Hydrolytic and sulfite yeasts contain 48-52% protein, 13-16% carbohydrate, 2-3% fat, 22-40% nitrogenfree extractive substances and 6-10% ash. Fodder yeasts increase the biological value of the proteins of other fodders on account of the irreplaceable amino acids contained in them. Fodder yeasts contain all ten vitally necessary amino acids in the following quantitites (as % of the dry matter of the yeasts):

Valine	3.1	Threonine	2.5
Leucine	3.7	Methionine	3.0
Isoleucine	3.5	Tryptophan	0.3
Arginine	3.2	Tyrosine	4.2
Lysine	4.4	Histidine	1.4

As regards content of amino acids, fodder yeasts are similar to proteins of animal origin.

To increase the effectivenes of use of the principal plant protein resources it is very important to introduce fodder yeasts into the fodder rations of animals. Fodder yeasts contain vitamins of group B and in that respect surpass all protein fodders, including even fish meal.

According to the data of P. N. Fisher [2] the following vitamins are contained in a kilogram of dry matter of yeast biomass (mg):

thiamin (B_1)	15-18
riboflavin (B_2)	54-68
pantothenic acid (B_3)	130-160
choline (B_4)	2600.0
nicotinic acid (B_5--PP)	500-600
pyrodoxine (B_6)	19-30
biotine (B_7H)	1.6-3.0
inosite (B_8)	5000
folic acid (B_9, B_{10}, B_{11}, B_cM)	3.4
cobalamin (B_{12})	0.08

The natural combination in yeasts of full-valued proteins and vitamins of group B proves to be very important in the nutrition of animals and poultry. The B vitamins are very closely connected with protein metabolism in the organism of animals and are components of enzyme systems and active catalysts necessary for the assimilation of amino acids and synthesis of protein.

Fodder yeasts are a rich source of vitamin D_2. Ergosterol contained in the fatty composition of yeasts (0.25-0.7% of the absolutely dry weight of the

yeast biomass), when irradiated with ultraviolet rays, is transformed into vitamin D_2. In one kg of irradiated fodder yeasts the vitamin D_2 content can be brought to 5000-12,000 international units. The ash of fodder yeasts also contains the following macro- and trace elements valuable to animals and poultry: phosphorus, potassium, calcium, iron, magnesium, sodium, sulfur, copper, manganese, cobalt and other substances. In total nourishment one kg of fodder yeasts contains up to 1.03-1.16 feed units and an exceptionally large amount of digestible (true) protein (up to 380-480 g).

The feeding of fodder yeasts in their natural form to animals and poultry is not recommended; they can be consumed only as a protein-vitamin additive to the feed ration.

A large number of investigations have been conducted of the feeding of yeasts to different species of animals and poultry. The high effectiveness of the use of fodder yeasts has been demonstrated by many agricultural scientific organizations in the USSR and abroad, and also by many years of practice.

A large number of experiments conducted during the fattening of pigs have shown that the introduction of yeasts into their feed in a quantity of 8-10% increases the gain in weight of the animals by 15-20% and reduces the expenditures of total fodder per unit of weight gain by more than 10%. Experiments have shown the great value of fodder yeasts for breeding sows: yeasts improved their general condition, increasing lactescence and reducing the mortality of the young pigs.

Fodder yeasts can be successfully fed to calves, cows and bulls. Yeasts can replace 20-30% of the whole milk standard during the fattening of calves and assure in that case daily weight gains of 650-750 g. During the raising of calves one kg of yeasts replaces 4-6 kg of milk and permits obtaining additionally up to 320 g of veal.

During the feeding of dairy cattle fodder yeasts increase the milk yield and the percentage of fat in the milk; the milk yield increases by 3-3.5 liters per day and the fat content by 0.4-0.6%.

Fodder yeasts are a valuable fodder for fur-bearing animals, replacing 30% of the meat standard. The systematic feeding of yeasts at wild-animal rearing farms has led to increased resistance of the animals to diseases and a considerable improvement of the quality of fur.

Yeasts increase the trotting ability and endurance of horses and reduce their fatiguability.

The use of fodder yeasts is especially effective in poultry raising. Poultry have a great need of protein feed containing a B-vitamin complex. Especially necessary are yeasts when poultry is kept in coops, and also in the raising of chicks. The addition of fodder yeasts to the ration in a quantity of 5%

of the total fodder weight increases the egg production of laying hens by 21-40% (depending on the breed of chicken). The addition to the ration of 10% of fodder yeasts increases egg production by 26-51%. A kilogram of yeasts fed to hens makes it possible to obtain an additional 30-40 or more eggs.

It has been established that at the Tomilinskaya poultry plant (Moskovskaya Oblast), which has been using fodder yeasts since 1952, the egg production of the hens increased from 140 to 203 per year. In addition, one kilogram of fodder yeasts permits obtaining an additional 2.2-2.9 kg of chicken meat.

Fodder yeasts are successfully used in raising valuable fish and in bee-keeping for the stimulative feeding of bees in the spring.

The mixed feed industry presents a great demand for fodder yeasts. In the formula of mixed feeds for various species of agricultural animals fodder yeasts constitute 3-5%, and in protein concentrates for pigs 15-20%.

According to data of the All-Union Institute of Animal Husbandry [3] the following quantities of yeasts are recommended for various animals and poultry as an additive to the basic fodder per head per day (g):

Horned cattle (bulls, cows)	500
Young horned cattle	300
Calves	200
Sows	250
Breeding gilts	250
Gilts being fattened	150
Sheep and goats	50
Working horses, brood mares	500
Foals	300
Fur-bearing animals	8
Mature poultry	5
Chicks	2

There is a mean standard of use of yeasts which has been established by practice: 1 g of dry yeasts per day per kg of live weight of the animal.

Consequently, fodder yeasts are being successfully used in all branches of animal and poultry raising. The requirements for fodder yeasts are increasing from year to year. The obtaining of hydrolytic and sulfite fodder yeasts is one of the directions of large-scale industrial production of fodder protein and vitamins.

The production of fodder yeasts is a relatively young branch of the national economy.

Scientific work on the enrichment of agricultural plant wastes in order to obtain from them concentrated carbohydrate and protein fodders was started in our country in the first five-year period.

In 1933 the planning of the Verkhnedneprovskiy experimental plant of fodder products for animals was begun, and it was put in operation in September 1935. Straw and corn cobs were the raw material. That plant was designed to produce from hydrolyzates crystalline xylose, xylose tanning agent, xylose syrup, glucose syrup and technical glue. Simultaneously work was done on the obtaining of protein fodder yeasts from hydrolytic sugar.

In 1936 at the Verkhnedneprovskiy experimental plant a shop for the production of fodder yeasts from pentose hydrolyzates of straw went into operation. Sugar-containing solutions obtained by mild acid hydrolysis, after neutralization, purification and cooling, were directed first into a fermentation section for fermentation of the hexose sugar, and then, after the ethyl alcohol was separated, the spent wash was directed to the growing of fodder yeasts. This was the first production experiment in the complex processing of plant materials into alcohol and protein fodder yeasts.

The results of the work of the installation at the Verkhnedneprovskiy experimental plant made it possible to proceed to the development of plans of industrial shops using the post-alcohol wash of hydrolysis plants to obtain protein fodder yeasts.

In 1939 the VNIIGS (All-Union Scientific Research Institute of the Hydrolysis and Sulfite Liquor Industry) conducted experiments on the growing of protein yeasts on the sulfite-alcohol liquor of the Krasnokamskiy plant. The positive results of that work also were used in the planning and construction of yeast shops. The first two industrial shops were put in operation in 1943 at the Khorskiy hydrolysis and Solikamskiy sulfite-alcohol plants. The technical equipping of the first yeast shops was not on a high level. Many processes were batch processes, including the main one, the growing of yeasts.

In the first years of the development of yeast production the main sugar-containing raw material was post-alcohol wash, since hexose sugar contained in the hydrolyzates and slufite liquors was used for the production of ethyl alcohol.

The obtaining of yeasts was to a certain degree production based on deeper use of organic substances in the hydrolyzates and sulfite liquors obtained at hydrolysis and pulp plants. It is understandable that the economics of those yeast shops, especially at the hydrolysis plants, in the first years was not at a high level. Still the effectiveness which yeasts gave in animal and poultry growing was very high and successfully repaid all expenditures on their production. With increase of the productive capacity and improvement of the technology the cost of yeasts at hydrolysis and especially at sulfite-alcohol plants was reduced considerably and in individual cases is 50-60% of the commercial price.

Until recently the post-alcohol wash of hydrolysis and sulfite-alcohol plants of pulp enterprises was the principal raw material for obtaining yeasts in

the hydrolysis industry. But those sources are inadequate for the development of fodder yeast production. The requirements of the national economy for fodder yeasts can be satisfied only if a multi-tonnage hydrolysis-yeast industry is created.

The hydrolysis industry has existed a little more than 30 years in our country. Its main direction has been the production of ethyl alcohol by the hydrolysis of inedible plant raw material: wood, various types of agricultural wastes (corn cobs, sunflower husks, cotton hulls, straw, cotton stems and reeds) and other plant materials.

Plants include organic compounds, including cellulose and hemicellulose (polysaccharides) forming as a result of complex biochemical transformations from very simple carbohydrates (saccharose). If the reaction of addition of a water molecule is carried out under appropriate conditions the inverse reaction can be obtained, as a result of which monosaccharides form from which polysaccharides (cellulose and hemicellulose) are constructed. This reaction, called hydrolysis, is accomplished on an industrial scale at the hydrolysis plants to obtain a sugar-containing solution.

The hydrolysis of cellulose to form glucose is accomplished according to the equation:

$$(C_6H_{40}O_5)n + nH_2O \rightarrow nC_6H_{12}O_6.$$

Cellulose water glucose

The reaction of hydrolysis of polysaccharides in essence does not occur at a normal temperature or in pure water. The hydrolysis of cellulose and hemicellulose, to accelerate the reaction, is carried out in the presence of catalyst (mineral acids -- sulfuric, hydrochloric, etc) and also at an elevated temperature. Thus, as a result of hydrolysis of polysaccharides it is possible to obtain hydrolysis sugar in the form of a solution (hydrolyzate). The sugar contained in the hydrolyzate consists of hexoses (glucose, mannose and galactose) and pentoses (xylose and arabinose). In its biochemical processing can be used to obtain ethyl alcohol, and pentose, which cannot be used for obtaining alcohol by fermentation, can be used to obtain fodder yeasts. Many operating hydrolysis plants work according to such a complex scheme of raw material use.

Schematic diagram 1 of the main production processes in obtaining ethyl alcohol and fodder yeasts during the hydrolysis of plant raw material is presented below [not reproduced]. According to that scheme plant raw material is subjected to hydrolysis by sulfuric acid diluted to 0.5-0.6% in hydrolyzers at a temperature of 175-190°. The furfural forming incidentally in that case is removed in the form of furfural-containing condensate, and a portion of it remains in the hydrolyzate. The lignin remaining after hydrolysis is removed from the apparatus. The obtained hydrolyzate, with a sugar content of up to 3-3.5% later undergoes inversion and neutralization by

milk of lime and ammonia water. The gypsum obtained as a result of lime neutralization, together with all the slurry is removed from the solution by precipitation in settling tanks or separation in eddy purifiers (cyclones). After purification from mechanical admixtures the neutralized hydrolyzate is cooled to 31-32°, after which it is fed for alcohol fermentation into the fermentation section of the hydrolysis plant. During fermentation, in addition to alcohol, carbon dioxide forms which is removed from the fermentation section. The mash obtained as a result of fermentation of the hexose into alcohol is directed for distillation and rectification, where the alcohol is separated from the mash and it is fortified to 95-96°, and different fractions (methanol, aldehydes, etc) are also separated. The mash from which the alcohol has been removed (the post-alcohol wash) mainly contains pentoses (0.7-0.8% of reducing substances) and after being cooled is directed toward the cultivation of fodder yeasts. To do that, seed yeasts of a pure culture and nutrient salts containing nitrogen, phosphorus, potassium and other elements necessary for the growth of yeasts are fed into a yeast-growing tank, and also air to provide oxygen for the formation of the yeast biomass and accomplishment of the respiration of yeast cells.

Grown yeasts are removed from the tank in the form of a yeasty finished mash which later passes through the stages of flotation and separation to remove the yeasts from the mash, washing and concentration. Then the yeast concentrate is evaporated to a 22-25% content of dry matter and dried to a moisture content of 8-10%. The obtained yeasts are packed in paper bags and sent to storage, and then to the consumer. During the formation of monosaccharides in the process of hydrolysis of plant materials a number of similar substances are formed -- furfural, oxymethyl furfural, methyl alcohol, pitch, organic acids and other substances. Many of them have no industrial importance and are even harmful in the process of biochemical processing of hexoses and pentoses into alcohol and yeasts.

From some substances (lignin, furfural, slurry and carbon dioxide) forming in the process of hydrolysis, valuable products are obtained for the national economy.

Fodder yeasts can also be obtained from dexoses. In this case, without obtaining ethyl alcohol, all the hexoses and pentoses contained in the hydrolyzates are utilized for fodder yeasts. The hydrolysis-yeast industry is now being developed on a large scale according to schematic diagram 2 [not reproduced].

According to that scheme plant raw material is subjected to hydrolysis in almost the same conditions (concentration of acid solution and temperature) as for scheme 1. Subsequent operations (inversion, neutralization, purification and cooling) also are similar to those operations in scheme 1, with the exception of specific auxiliary operations in the preparation of the cycle (the feeding of a larger quantity of nutrient salts, a greater degree

of removal of furfural, deeper cooling and dilution of the wort with water and spent wash). The yeasts are grown at higher concentrations of sugar in the wort. Feeding of ammonia water is required as a source of nitrogen for the microbiological synthesis of protein and to maintain the pH value of the medium. Flotation, separation, evaporation and drying of the yeasts are similar to those operations in scheme 1.

According to both schemes of use of plant raw material at hydrolysis enterprises, the following quantities of commercial product can be obtained from one ton of absolutely dry coniferous wood (Table 1).

Table 1

Product	Scheme 1 Obtaining of alcohol and yeasts	Scheme 2 Obtaining of yeasts
Ethyl alcohol (absolute), liters	175 - 182	-
Fodder yeasts (10% moisture content), kg	32	225 - 235
Methanol, kg	2.0	2.0
Fusel oils, kg	0.3	-
Furfural raw material (94%), kg	5.6	5.6
Lignin (absolutely dry), kg	380	380
Carbonic acid (liquid), kg	70	-
Gypsum floor, kg	225	225

Sulfite liquor, earlier considered a harmful waste of pulp plants, is now used more and more to obtain alcohol and yeasts. Sulfite liquor is a solution containing sugar that is obtained during the sulfite digestion of cellulose. The digestion of cellulose is in essence also a process of hydrolysis, but under different conditions: at a temperature of 130-140° and in an aqueous solution of sulfur dioxide containing some sort of base (calcium, magnesium, sodium or ammonium). During the digestion of cellulose lignin, hemicelluloses, pitch, fats and mineral salts are dissolved. Cellulose remains as the product of production. The liquor contains monosaccharides obtained as a result of hydrolysis of the hemicelluloses. In that case the monosaccharides also consist of hexoses and pentoses and can be used to obtain ethyl alcohol and fodder yeasts or fodder yeasts alone. Shown in schematic diagram 3 [not reproduced] are the main production operations in obtaining ethyl alcohol and fodder yeasts from sulfite liquor.

According to that scheme wood is subjected to chemical processing (hydrolysis) with an acid cooking liquor containing up to 6-8% sulfur dioxide prepared on some sort of base. The process is carried out at a temperature of 130-140° in special cookers. After completion of the digestion all the contents of the cooker are discharged into drainage pits from which the sulfite

liquor is pumped away through a sample take-off into a container. After removal of the liquor and washing the cellulose goes for further processing and the sulfite liquor passes through the stage of purification (filtration) of the cellulose, if it is drawn off in unallowably small quantities with the liquor, and also the blowing away by steam of the sulfur dioxide contained in unallowable quantities on special packed and plate columns. These operations as a rule are accomplished directly at the pulp plant. The sulfite liquor thus prepared goes to the sulfite-alcohol plant, where the liquor is neutralized by milk of lime or ammonia water, and then the neutralizate is purified of the forming sludge. After purification the neutralized and purified sulfite liquor containing up to 2.5-3.0% sugar, after passing through preliminary cooling, enters the fermentation section for alcoholic fermentation. The carbon dioxide evolved in that case is vented to the atmosphere or used with the obtaining of liquid cooking, solid technical or edible carbon dioxide. The mash obtained as a result of fermentation of hexose into alcohol is directed to distillation or rectification, where the alcohol is separated from the mash and fortified to 95-96°, and various fractions, mainly methanol, also are separated. The dealcoholized mash (spent wash) containing mainly pentoses (0.7-0.8% of reducing substances) after cooling enters the growing of yeasts. The growing of yeasts and all subsequent operations in accordance with scheme 3 are very similar to the operations in the processing of spent wash for fodder yeasts of hydrolysis production, which will be discussed in detail in special sections.

Fodder yeasts can be obtained from the hexose part of the sulfite liquor without obtaining ethyl alcohol (scheme 4) [not reproduced]. In that case all the sugars -- hexoses and pentoses -- are utilized for yeasts. Yeast shops of an entire series of pulp plants (Talininskiy, Klaypedskiy, Kondrovskiy, Ingurskiy, etc) are working according to that scheme. All operations on the preparation of the liquor at the pulp plant: the collection of the pulp and sulfite liquor, purification of the liquor from cellulose fibers and the blowing of sulfur dioxide from it, are accomplished in the same way as in scheme 3. Subsequent processes differ sharply from those of scheme 3. Neutralization of the sulfite liquor with milk of lime and its purification from sludge are omitted. The sulfite liquor blown free of sulfur dioxide is cooled and enters directly into the yeast-growing tanks for growing. During the growing, besides necessary seed yeasts and nutrient salts (nitrogen, phosphorus and potassium) and air, ammonia water is fed into the tank to maintain the pH value. Taking into consideration that the liquor is highly acid, ammonia water is fed into the tank, neutralizing the acid liquor to a definite pH value. To maintain a definite concentration of regulating substances the wort is diluted with water and spent mash.

The flotation, separation, evaporation of concentrate and drying are accomplished similarly to corresponding processes of the above-described schemes, with the exception of the washing of yeasts.

According to both schemes of use of sulfite liquor, in the processing of 1 ton of absolutely dry coniferous wood the following quantities of commercial product can be obtained (Table 2).

Table 2

Product	Scheme 3 obtaining of alcohol and yeasts	Scheme 4 obtaining of yeasts
Ethyl alcohol (absolute), liters	35 - 45	-
Fodder yeasts (10% moisture content), kg	15	50 - 60
Methanol, kg	1	
Fusel oils, kg	0.1	-
Carbonic acid (liquid), kg	20 - 25	-
Mash concentrates with 55% moisture content, kg	550 - 600	480 - 520

Besides sulfite liquor, still another type of raw material containing sugar, prehydrolyzates of sulfate-pulp production, to obtain fodder yeasts of the pulp industry. To obtain fodder yeasts the prehydrolyzate must be prepared in advance. It contains mainly pentoses and polysaccharides which before use must undergo inversion -- hydrolysis of polysaccharides in aqueous solution by mineral acid at a corresponding temperature, with the formation of monosaccharides on which fodder yeasts can be raised as described in the preceding schemes. The use of prehydrolyzates of the sulfate-pulp industry in the production of fodder yeasts has been organized for the first time in the world at the Bratsk Lumber Industry Complex. In addition, protein-vitamin yeasts can be obtained from petroleum hydrocarbons or from synthetic n-alkanes of natural gas.

Fodder yeast production is on a different level in foreign countries. Very great successes have been achieved in this branch of industry by the GDR, France, the USA and some other countries. In France a large contribution has been made to the improvement of the technology for obtaining yeasts by the Soris Company. This company has done part of the planning and design work for the Soviet Union. Some of these solutions will be included in the corresponding chapters of this book.

In the Soviet Union the large-scale construction of special hydrolysis-yeast plants, and also of separate yeast shops and plants within pulp enterprises, has become possible thanks to available scientific and production achievements in that area.

During the period of development of the yeast industry, in scientific and planning organizations, and also at enterprises, an entire series of qualified specialists have been developed who have made a large contribution to fodder yeast production. This has made it possible for the yeast industry of the USSR to enter first place in the world both in scales of production and in the technique and technology of obtaining fodder protein yeasts.

Chapter 2. Raw Material for Fodder Yeast Production

Sources of Raw Material

In the accumulation of the biomass of yeasts the carbon source can be sugar: glucose, xylose, maltose, saccharose, mannose, galactose and arabinose, and also acetic acid, ethyl alcohol and other organic substances. Some quantity of carbohydrates is contained in wastes of the food industry, which can also be used for growing yeasts. Among such wastes are the post-alcohol wash of plants of ethyl alcohol production by the biochemical method from molasses, grain and the potato, the juice waters of starch plants, the waste liquor obtained in the lime separation of molasses and the wastes of some other food production. The quantity of yeasts that can be obtained at those plants is determined by the quantity of wastes. In our country their resources are relatively small.

A considerable quantity of fodder yeasts can be produced from plant raw material. At hydrolysis-alcohol and sulfite-alcohol plants the post-alcohol mash is used to grow yeasts. At some pulp and paper combines a sugar-containing solution, called the prehydrolyzate, can also be obtained in the process of sulfate digestion. After inversion the prehydrolyzates are suitable for the production of yeasts. The liquor obtained in the sulfite method of digesting pulp is widely used to make ethyl alcohol. The same liquor can be used to produce yeasts. Some types of sulfite liquor ought not be processed into ethyl alcohol in view of their considerable content of hexoses. Among them is the liquor from the digestion of high-yield pulp. The requirements of the national economy of the USSR for fodder yeasts can be satisfied only to an insignificant degree through use of the above-enumerated wastes of the pulp industry. A larger amount of yeasts must be obtained from other, larger sources of raw material. In our country such raw materials are the wastes of the wood of coniferous and deciduous species of trees and the wastes of agriculture (sunflower husks, corn cobs, cotton stems and bolls, reeds, etc). Plant raw material is very varied in its properties and particle size distribution. In origin it can be divided into two groups: 1) wood raw material (perennial plant tissues) and 2) plant wastes of agriculture (one-year plant tissues).

Wood raw material is divided into coniferous and deciduous. Those two types are identically suitable for yeast production. In the total balance of wood raw material the coniferous amounts to about 70% and the deciduous to 30%. Of the conifers, used most often are the pine, the spruce and in regions of Eastern Siberia, the larch. Of deciduous species, the birch and aspen predominate. Wood raw material arrives at hydrolysis plants in the form of firewood or sawmill wastes. Because of the high cost of firewood it is less advantageous to use it for yeast production. In addition, firewood must be transformed into technological chips, and that causes additional operating expenses.

Wood wastes are divided into the following types:

1. wastes of sawmilling (hard and soft: slab, squared timber, sawdust, chips, etc);
2. wastes of veneer, furniture, match and other production (veneer sheets, "pencils", etc);
3. wastes of the production of tanning extracts (tan waste);
4. wastes of rosin extraction plants (chips after tar has been extracted);
5. felling wastes.

Many of these wastes (sawdust, shavings, tan waste and chips after extraction) are suitable for hydrolysis without any additional processing. Other types of waste (slab, laths, veneer sheets, "pencils" and felling wastes), however, require grinding and screening. The quality of wood raw material is determined by the specifications of MRTU (Interrepublic Technical Specifications) 13-02-3-66.

According to the technical specifications chips for hydrolysis production must have the following dimensions (mm):

Length along the grain	3 - 35
Thickness	up to 5

The dimensions of sawdust are not standardized. The raw material can contain up to 1.0% of mineral admixtures (dust and sand), up to 6% of rot and up to 12% of bark. The presence of charred particles is not allowed.

Wastes containing adhesive or impregnating materials cannot be used as raw material for hydrolysis-yeast plants if those substances are toxic to yeasts (for example, wastes obtained in the processing of glued furniture).

Tan waste is the waste of the production of tanning extracts. Before extraction, oak wood is ground into chips. Chip sizes are not uniform and vary from 3-6 to 45 mm. About half the chips consist of fractions with particle sizes of 5-15 mm. The moisture content of the tan waste is 52-60%. Tan waste can be used for hydrolysis without pre-treatment.

Extraction chips are the waste of rosin extraction plants. Before the extraction, pine stumps are ground into technological chips which in size satisfy MRTU 13-02-3-66. The moisture content of the chips after extraction is 8-10%. The specific yield of sugars from it is about 10% less than their yield from ordinary wood. Extraction chips do not require pre-treatment.

Felling wastes, consisting of 15% coniferous needles or branches, 25% bark and 60% wood, contain about 15% less reducing substances than ordinary wood raw material [1]. The yield of reducing substances is 36% from coniferous species and 42% from deciduous instead of 46-48%. The quality of hydrolyzers also is lower, as a result of which the yield of yeasts from the reducing substances is below the normal. In processing felling wastes a yield of yeasts of 40-42% instead of 46-48% can be obtained from reducing substances. In dimensions the ground felling wastes can correspond to ordinary wood wastes (MRTU 13-02-3-66), but in contrast with them have a higher content of bark and decay.

The forest resources of our country are irregularly distributed. In some regions wood cannot be used as raw material for yeast production and it is necessary to draw in other, local types of raw material. For example, in Tselinnyy kray the production of fodder yeasts can be organized only on the basis of processing the straw of cereals; in Uzbekistan on the basis of three types of raw material: cotton hulls, cotton stalks and some medicinal grasses (for example, the tow of ambari-hemp); in the Ukraine and Northern Caucasus sunflower husks and corn cobs can serve as raw material.

Of a great variety of plant wastes of agriculture corn cobs and sunflower husks have obtained the greatest industrial application in the hydrolysis industry. These types of raw material are concentrated at oil-mills and plants for the grading of corn seed. To organize yeast production of 10,000-14,000 tons a year that raw material must be transported from several plants. Both types of the indicated raw material can be processed simultaneously at a single plant. Before sunflower husks are fed into production it is advisable to pass them through rollers to increase the specific load of the hydrolysis apparatus.

At hydrolysis plants on the territory of the Uzbek SSR cottonseed hulls are now being processed according to a complex system with the use of pentoses for the production of xylitan and of hexoses for yeast production. The amount of cottonseed hulls processed at hydrolysis plants is insignificant in the total raw material balance.

One of the types of raw material for the Uzbek SSR and other cotton regions of our country could be cotton stalks. According to the data of V. S. Minina [2], from cotton stalks a yield of reducing substances can be obtained in the range of 35-38% of the absolutely dry weight of the material, and a yield of yeasts of up to 50% from the obtained reducing substances. The annual renewal of the quantity of cotton stalks in the Uzbek SSR is such that from that raw material one can produce a considerable quantity of yeasts. To make the use of cotton stalks economically advisable it is necessary to organize the batch production of machines to collect and grind it. It is advisable that cotton stalks arrive at the hydrolysis plant already ground. This will facilitate the loading and unloading work. The absence of such machinery makes it impossible for existing hydrolysis plants in the cotton regions to widely use that type of raw material.

It is known that the yield of yeasts from reeds is only 10% less than from wood and can amount to 195-210 kg per ton of absolutely dry material. The yield of yeasts from reducing substances is up to 50% or more. The mass processing of reeds is possible after collecting machines are developed and produced in the necessary quantity. In view of the limited zone of reed propagation in our country its proportion in the total balance of raw material intended for yeat production is insignificant.

It is considered possible to obtain a yield of yeasts from straw of 180 kg per ton of absolutely dry raw material. For convenience of transport the

straw must arrive at a plant in bales weighing 15-20 kg, with dimensions of 360 x 500 x 800-900 mm or other dimensions according to the transport conditions. Bales of straw are tied with wire or paper cord. It is advisable to grind the straw before feeding it to the hydrolysis apparatus. The obtained chopped straw must have a length of 100-120 mm. There are two negative factors in grinding: the need to use manual labor to untie the bale bound with wire or cord, and the very insignificant specific loading density of the hydrolysis equipment with raw material (70-90 kg/m^3) in connection with the loosening of the straw. To increase the specific loading of the equipment it is best to pack the straw in small bales, binding them only with cord (twine) and to feed it into the hydrolysis equipment in unbound and unground form.

Ambari-hemp tow is used as yet at only the Yangi-Yul'skiy Hydrolysis Plant as raw material.

Investigations conducted at the Krasnodarskiy Hydrolysis Plant [3] have shown the complete suitability of using rice hulls to obtain hydrolyzate containing 2.36% reducing substances, which assures a yeast yield of 47-49% of the reducing substances. Rice hulls retain good filtering capacity, and this assures the normal removal of hydrolyzate from the hydrolysis equipment.

In recent years investigations have been conducted on the use of large peat resources with a low degree of decomposition (up to 20%) as raw material for yeast production. In the European part of the RSFSR alone more than 60 plants with a total capacity of about 1.3 million tons a year can be supplied with such raw material [4]. According to one variant of the process flow diagram, peat with a moisture content of 80-85% undergoes hydrolysis. A method has been developed for the continuous hydrolysis by sulfuric acid diluted to 5% at a temperature of 150°C with a yield of 23% reducing substances. The residue, pressed to a moisture content of 40-42%, is to be used as fuel. This type of yeast production can prove to be very advisable, as it can be solved in a complex with the construction of heat and electric power stations. According to the second variant of use of peat it is proposed to hydrolyze peat, dried to a moisture content of 15% in apparatus of the screw-conveyor type, by concentrated sulfuric acid with a modulus of 0.2. It is thought that in that case 330-335 kg of reducing substances can be obtained from 1 ton of absolutely dry peat.

Preparation of Raw Material and Feeding It to Production

The reception, storage, grading (removal of extraneous admixtures) and feeding of raw material to production are usually accomplished in the raw materials shop of a hydrolysis plant.

Depending of the loacation of the raw material source (lumber mill, wood storage, etc) the raw material is delivered to a hydrolysis-yeast plant by

motor vehicle, railroad, continuous mechanical or pneumatic transport. The equipment for the reception of raw material depends on the type of raw material, transport and storage. Receiving hoppers are erected for the reception of ground raw material from railroad cars and trucks. Cyclones are installed for raw material fed by pneumatic transport. The received raw material is directed toward current or reserve storage. Depending on the type of raw material and climatic conditions, a method of storing it is selected -- open or closed. The current storage usually is located near the hydrolysis section. Such storage must accommodate a stock of raw material for 3 or 4 working days. The reserve storage is designed for a larger capacity of raw material (15-20 days' supply).

Soft wastes (sawdust and shavings) and hard wastes (firewood, slab, etc), bales of straw and packets of cotton stalks are delivered to the hydrolysis plant. The type of transportation also is selected accordingsly.

In accordance with the requirements of the technology the raw material must be ground to definite dimensions. The grading is done for that purpose on a stationary screen or on mechanical sorters installed in the flow of raw material.

If the plant processes two or three types of raw material a corresponding section in the current storage is provided for each type. Each storage unit is provided with suitable storage loading and unloading equipment and sections or containers for the storage of raw material. The raw material is stored in piles or in bunkers. The storage in piles is subdivided in turn into open and closed. In the storage in piles the raw material is poured on a prepared area. The open storage units are constructed for raw material that is soft or perishable from the effect of moisture.

The piles are built up and unloaded with a bulldozer which moves the raw material to a loading hopper of an elevated belt conveyer that feeds it into the production building. Corncobs are unloaded from the open storage unit by scraper equipment. The formation of the pile and movement of the raw material over the storage area, outside the limits of action of the scraper, is accomplished with grain-handling equipment.

At many plants the storage unit is loaded by means of a horizontal scraper or a belt conveyer located on the upper gallery of the storage unit. The raw material is poured down from it, forming a pile. The conveyer for unloading the storage is built in an underground passageway. To store raw material and protect it against rain or scattering by the wind a pyramidal building is provided in which the loading conveyer is placed.

The bunker storage of raw material is carried out in a metallic or reinforced concrete square or circular bunker. There are openings in the lower part of the bunker for unloading the raw material. A revolving feed table is installed to regulate the amount of raw material unloaded from the bunker. Storage of the bunker type has a number of advantages, namely compactness and lower operating expenses.

Raw material is fed from storage into the hydrolysis apparatus by a system of transporting equipment arranged in series that feeds raw material to a distributing transporter installed above the hydrolyzer. Scraper or belt conveyers are used most often, pneumatic transport more rarely. Scoop elevators are used to feed the raw material vertically. The raw material fed to the hydrolysis section must be freed of metallic objects. Magnetic separators are installed on the transporters for that purpose.

The raw material, freed of metallic admixtures, is fed to the distributing transporter of the hydrolysis section. At most plants that transporter is made in the form of a belt conveyer that can be stationary or mobile -- in reserve.

Chapter 3. Obtaining Hydrolyzate and Preparing It for Yeast Growing

General Information

The main task of the technological process of hydrolysis and the preparation of hydrolyzate is to obtain biologically high-quality sugar-containing solution in order to obtain fodder yeasts from it. In the process of hydrolysis, besides substances necessary for the growing of yeasts, other substances form which inhibit the multiplication of yeasts. Among such substances are furfural, oxymethyl furfural, uronic acids, uninverted sugars (dextrins), colloidal substances and some others.

Complete removal of harmful admixtures is not successfully achieved by means of methods of preparing hydrolyzates for the growing of yeasts known in technique and technology at the present time. Those methods permit only to a certain degree reducing the content of harmful admixtures. Therefore the primary task of hydrolysis is the obtaining of hydrolyzate with a minimum content of harmful admixtures, which during further processing must be eliminated from the composition of the sugar-containing solution entering the yeast-growing section. Investigations and the practice of existing plants have established the maximally allowable content of some of the harmful substances. For example, the furfural content must not exceed 0.03-0.04% in the wort [1] and 0.08-0.12% in the hydrolyzate. The hydrolyzates obtained in different methods of hydrolysis have different degrees of quality.

Methods of Hydrolysis

The polysaccharides contained in plant tissue, to be assimilated by yeasts, must be converted into monosaccharides, and this is done by a chemical method in the process of hydrolysis. To accelerate hydrolysis, catalysts are used, the most active of which are mineral acids. Only some acids have obtained practical application: sulfuric, sulfurous and hydrochloric. Hydrolysis can be carried out using concentrated acids or their aqueous solutions of low concentration (0.5-5%). In connection with that, hydrolysis by dilute and concentrated acids differs.

Sulfuric and sulfurous acids are used for hydrolysis with dilute acids. Dilute hydrochloric acid is not used in view of its strong aggressiveness, which gives rise to difficulties in providing apparatus for the process. Sulfurous acid has two-fifths the catalytic capacity of sulfuric.

At present the hydrolysis plants of the Soviet Union are widely using dilute sulfuric acid for hydrolysis. The hydrolysis is carried out at temperatures of 175-190° and a pressure corresponding to that temperature. The sulfuric acid concentration is 0.4-0.6%. During hydrolyis, reducing substances form, by which is understood the sum of the monosaccharides and other substances having an aldehyde group, which are determined on the basis of ability to reduce cupric into cuprous oxide in an alkaline medium.

Chapter 4. The Obtaining of Sulfite Liquors and Their Preparation for the Growing of Yeasts

General Information

Sulfite liquor has long ceased to be a waste of pulp production and is one of the principal raw material sources for the obtaining of various products: ethyl alcohol, methanol, fodder protein yeasts, vanillin, mash concentrates, carbon dioxide, tanning extracts, etc. Most widespread is the production from sulfite liquors of ethyl alcohol and fodder protein yeasts, which are a deficit type of product in the national economy.

Sulfite liquor is not the main type of product of pulp production, but represents a solution of complex organic compounds accompanying the production of pulp. To some degree the digestion of wood to obtain pulp can be regarded as a process of wood hydrolysis when sulfurous acid is the catalyst.

Whereas previously in the sulfite pulp industry the raw material was only coniferous wood, now many other types of raw material are used: deciduous wood, reeds, straw, etc. The technology of pulp production also has changed correspondingly, and in connection with that also the quality of the sulfite liquors used for the production of ethyl alcohol, fodder yeasts and other types of product during the complex use of all the organic part of the solution obtained during the digestion of cellulose. Besides calcium, various bases are widely used: sodium, magnesium, ammonium and mixed bases (soda-potash, ammonium-calcium, etc).

In the sulfite pulp industry the production of high-yield pulp and hemicellulose has increased in recent years. This also has led to a qualitative change of the obtained sulfite liquors.

The broad variety of pulp digestion conditions implemented and designated by new plans did not in a brief period of time provide scientific organizations with the possibility of completely studying the quality of the different sulfite liquors. Therefore in proportion to the conducting of laboratory

investigations and also production tests the new distinctive features of the use of sulfite liquors will be revealed. Presented in the present chapter is basic information about the obtaining of sulfite liquor and its preparation for the production of fodder yeasts when different types of raw material and different conditions are used for sulfite cooking.

The most widespread method of obtaining pulp is the sulfite method, consisting in the fact that ground raw material (wood, reed, straw, etc) is processed at temperatures of 140-160° with bisulfite cooking acid which is a catalyst. In that case lignin is sulfurized and dissolved and hemicellulose is also dissolved and hydrolyzed. The pulp remains in the solid phase, as sulfurous acid practically does not dissolve it. At the conclusion of the digestion the solution with the organic and mineral substances which have gone over into it is separated from the pulp. After being washed with water the pulp is directed to further processing and the separated solution, called the sulfite liquor, is used for the production of alcohol, yeasts and other types of production. As a rule, under present-day conditions the sulfite liquor must be used complexly, with the obtaining of the maximum quantity of product from it, without discharging the organic part of the solution into the sewer. Practically complete processing of sulfite liquor is the implementation of a definite sequence of biochemical utilization of six-atom (fermentable) sugars for ethyl alcohol, five-atom sugars (not fermentable into alcohol) for protein fodder yeasts and the lignosulfite complex for different products.

In spite of the fact that sulfite liquor is a by-product of sulfite-pulp production, nevertheless up to 50% of the organic part of the wood goes over into it, the full-valued use of which is of great national economic importance. For successful use of the sulfite-liquor it is necessary in the process of digestion, without deterioration of the pulp quality, to obtain high-quality liquor suitable after corresponding processing for the production of various types of product.

Depending on the type of raw material and the base, the digestion conditions, the pulp yield and other factors, the quality of the liquor is also determined. Not all sulfite liquors can be used to obtain ethyl alcohol. For example, the liquor from the digestion of pulp from the wood of deciduous species, and also from the digestion of high yield pulp from coniferous species, should be used to obtain ethyl alcohol in view of the extremely low yield of it from the reducing substances contained in the liquor. That liquor is suitable for obtaining fodder protein yeasts. For other liquors, obtained, for example, on non-calcium bases, additional treatment is required (purging with steam and air) in order to obtain the maximum yield of alcohol or yeasts.

All types of sulfite liquors can be used to obtain fodder yeasts, but each of them, before being fed to the yeast-growing section, requires corresponding processing, depending on a whole series of factors connected primarily with the pulp digestion conditions.

At some pulp enterprises, during the digestion of sulfate pulp and during aqueous hydrolysis in the initial stage of digestion, a liquid is obtained that is called the prehydrolyzate. That prehydrolyzate contains sugar of various composition which after corresponding processing (inversion) can also be used to obtain yeasts.

Chapter 5. The Growing of Yeasts

General Information

Various sugar-containing solutions are used as nutrient media for the growing of fodder yeasts. Sugars contained in hydrolyzates, sulfite liquors or prehydrolyzates are used for those purposes at enterprises of the hydrolysis and pulp and paper industries. Whereas the methods of preparing nutrient media from all those types of sugar-containing solutions are different, the methods of processing them into yeast are similar in many respects. Therefore the description of the technological systems and also of the conditions for obtaining yeasts from all the types of nutrient media will be combined. Only when necessary will a certain distinctive feature typical of some types of nutrient media be pointed out.

The production and technological process for obtaining yeasts from prepared substrates is divided basically into the following operations (scheme 5) [not reproduced]:

- the growing of seed yeasts of a pure culture;
- the growing of commercial yeasts;
- separation of yeasts from the suspension by flotation and separation during simultaneous washing of the yeasts with water, and condensation of the yeast suspension;
- vitaminization;
- plasmolysis;
- dehydration of the yeast suspension by evaporation to obtain the yeast concentration;
- drying of the yeasts and storage of the finished product.

In the technological system of yeast production the stage of growing yeasts is the main operation based on microbiological synthesis. For the accumulation of the yeast biomass it is necessary to have a corresponding container, that is, apparatus for the growing of commercial fodder yeasts, seed yeasts of a pure culture, a nutrient medium and air.

Each of those factors is of importance in the process of growing yeasts. After yeasts are grown they must be separated from the spent medium, washed and dried. Yeasts are separated and dehydrated by flotation, separation, filtration, evaporation and drying. Thus the technological operations in obtaining yeasts are divided into the biochemical, mechanical and thermal.

During the years of development of fodder yeast production all the operations of the technological process have proceeded along a definite path of technical

improvement. Scientists, specialists in planning and production, and also the leading workers and rationalizers of production have done much work on the improvement of technological processes, individual operations, and the designs of equipment for the growing and dehydration of yeasts. All the production processes are continuous. Experience in production has made it possible to proceed to the development of a technology and apparatus for enterprises with a large capacity.

The finished fodder yeasts, according to TU-143-52, in quality must satisfy the following requirements. The yeasts are a dry powder in the form of flakes or granules, brown in color, with a taste and odor characteristic of yeasts. Strange taste or odor is not allowed. The physicochemical indicators are: a moisture content not over 10%; an acidity (in mg of acetic acid per 100 g of product) not over 900. The content of total protein must be at least 45%. The content of true protein must be at least 35%. The ash content must not be over 12%.

Chapter 6. Separation of the Yeast Biomass from the Spent Medium and Its Concentration to Commercial Product

General Information

Commercial fodder yeasts must be obtained in the dry form with a moisture content of not more than 10% (TU 143-52). Consequently, all the moisture contained in the finished mash with the yeasts, after emergence from the yeast-growing apparatus must be removed. The finished mash with the yeasts usually contains 20-40 g of yeast biomass (with a moisture content of 75%) per liter. The yeast biomass itself also has an intracellular moisture content of up to 75%. Thus the quantity of dry matter in the finished mash containing yeasts usually is one fourth the quantity of the yeast biomass expressed in terms of weight (g/liter). For example, one liter of mash containing 20 grams of yeast biomass per liter contains 5 g of dry matter, that is, 0.5% of the weight of the finished mash. Thus to obtain absolutely dry yeasts from finished mash containing yeasts with those indicators, for each kg of dry mass it is necessary to remove 199 kg of moisture from the finished mash: 3 kg of intracellular and 196 kg of intercellular. If it is taken into consideration that commercial yeasts must have a moisture content of up to 10%, the total quantity of moisture removed per kg of commercial yeasts sill be somewhat less. Table 13 presents data on the amount of moisture to be removed from finished mash, as a function of the yeast contained in it.

The data of Table 13 show how important it is to increase the yeaat content in the finished mash coming from the yeast-growing apparatus. With increase of the concentration of yeast biomass in the finished mash the specific expenditures on the removal of excessive moisture are sharply reduced.

Table 13

Quantity of yeasts in the mash, g/liter	Content, g/liter		Quantity of moisture removed per kg of commercial yeasts, kg
	absolutely dry yeasts	total moisture	
10	2.5	997.5	363
20	5.0	995.0	181
30	7.5	992.5	122
40	10.0	990.0	90

Various methods are known for separating the yeast biomass from the finished mass, but the principal, widely known methods are mechanical and thermal engineering methods. Mechanical methods include filtration, settling, centrifugation, separation, hydrocyclone separation and others. Thermal engineering methods include evaporation and drying.

Besides mechanical and thermal engineering methods, ultrasonics are used in some branches of industry to separate solid substances from suspensions. However, this method has not yet been developed for the separation of yeast biomass from the finished mash.

Single fodder yeast cells have a circular or oval form, and sometimes they are grouped in the form of branches. Single cells have an average diameter of 5-7 microns. They are finer than the yeasts of alcohol fermentation. Their specific gravity is slightly greater than that of the liquid in which they are present. Therefore the separation of yeasts by settling or purification on hydrocyclones is not applicable. The separation of yeasts by the natural method proceeds extremely slowly. Methods based on the difference of specific gravities of the yeasts and liquid (of the hydrocyclone) also are unsuitable, as the yeasts are not separated at the small velocities that are developed in a hydrocyclone. Ordinary centrifuges, developing velocities insufficient for the separation of yeasts from the liquid, cannot be used, basically for the same reason. Only separators with a number of revolutions reaching 5000-6000 per minute separate yeast cells from the liquid.

The separation of yeasts from a suspension by filtration also is possible. A number of enterprises use this method. However, it has shortcomings. Moisture can be removed by evaporation. The drying of yeasts in various types of dryers also is suitable as a means of dehydration in the last stage of production of commercial yeasts.

In recent years the method of flotation has been widely used to separate yeasts from the finished mash. It uses the ability of yeast cells to be floated from the spent medium enriched with air and including very fine solid particles.

Thus, of all the methods of removing excessive moisture the most acceptable for obtaining dry commercial yeasts are flotation, separation, filtration,

evaporation and drying. Each of them is suitable in a definite stage of dehydration: flotation and separation are best for weak concentrations of yeast biomass in the mash, and filtration, evaporation and drying for a condensed yeast suspension. Besides the technical suitability of a given method, each of them should be evaluated for economic advisability (capital investments, expenditures of steam, electric power, manpower, etc).

In the separation of a yeast suspension on separators the main expenditures are of electric power and manpower on servicing. Shortcomings of separators are: the relatively low productivity of each unit of equipment, and also the need for systematic shutdown to clean them because they become clogged. Separators are not classed as completely continuously operating machines.

Less electric power is required for the filtration of yeast biomass on vacuum filters than on separators, but in filtration the yeast suspension must be more concentrated. Larger expenditures are required on the operation of filters (manpower and materials). The specific expenditures also are higher on the erection of buildings when vacuum filters are used.

During the evaporation of yeast concentrate on evaporators mainly heat (low-pressure steam) is expended. To reduce steam expenditures, double- or triple-effect vacuum evaporation units are built. The specific capital investments on equipment are not high. However, the evaporation of yeast concentrate with a content of dry matter greater than 23-25% is unallowable on account of increase of its viscosity.

During the elimination of moisture from yeast concentrate in spray dryers steam or heat is expended in the form of other heat transfer agents. In that case electric power is expended on spraying and pumping the concentrate, etc.

Expenditures on the installation of roller dryers for small capacities are considerably less than those on the equipment of spray dryers with a similar capacity. In the selection of certain methods of drying yeasts they should be compared not only with respect to capital investments but also to operating expenses. For example, when steam is cheap, for the concentration of yeast mass the installation of an evaporator is very advisable, and when the fuel used to preheat the heat-transfer agent is very cheap (gas, fuel oil, etc), it is advisable to install a spray dryer and separate all the moisture with it, without any evaporation. In practice it is most advisable of all to have both an evaporator and a dryer because, if the moisture is removed only by drying, large dryers are necessary, and that leads to increase of the capital investments and heat expenditures.

Through economic and technical evaluation of various methods of removing moisture from yeast biomass the following most advisable technological alternatives were determined:

Table 15

	A Завод	B Вид дрожжей	C Условное обозначение расы дрожжей	D Содержание витаминов, мкг, на 1 кг сухого вещества дрожжей: 1 тиамина	2 рибофлавина	3 никотиновой кислоты	4 фолиевой кислоты	E Содержание эргостерина, %
a	Канский	Candida utilis	К-2	10,9	37,4	417	35,3	0,38
b	Лобвинский	Candida albicans	Л-2	15,3	63,5	402	16,5	0,44
c	Красноярский	Candida Sp.	Кр-9	18,3	48,6	326	18,0	0,40
d	Хорский	Candida Sp.	Х-9	12,1	54,6	405	7,5	0,24
e	Саратовский	Candida tropicalis	СД-5	17,4	47,1	411	18,0	0,41
f	Соликамский ЦБК	Candida utilis	С-1	5,6	25,9	415	26,4	0,48
g	Московский	Saccharomyces cerevisiae	ЛБД-11	28,4	28,5	157	15,5	1,24

Key: A - Plant B - Species of yeasts C - Conventional symbol for race of yeasts D - Content of vitamins, in micrograms, per kg of dry matter of yeasts E - Ergosterol content, %
1 - Thiamin 2 - Riboflavin 3 - Nicotinic acid 4 - Folic acid
a - Kanskiy K-2 b - Lobvinskiy L-2 c - Krasnoyarskiy Kr-9 d - Khorskiy Kh-9 e - Saratovskiy SD-5 f - Solikamskiy Pulp and Paper Combine S-1 g - Moskovskiy LBD-1
Note: Brewer's yeasts were taken after the change of the Moscow Yeast Plant to a new race characterized by a considerably larger content of ergosterol than many other cultures of brewer's yeasts.

I flotation, separation, evaporation and drying;
II flotation, separation, filtration and drying;
III flotation, separation and drying;
IV separation, evaporation and drying;
V separation and drying.

All these alternatives have been implemented in practice at a number of existing plants.

To obtain fodder yeasts of high quality an obligatory operation, the washing of yeasts, is included in the system of moisture removal with flotators and separators. In that case almost all the spent medium in which the yeast was grown is washed away.

Alternative I is the most widely distributed scheme of processes for the separation of yeast biomass from mash.

According to alternative II, included in the scheme, besides flotation and separation of yeasts, is filtration of the yeast biomass. This operation

Table 16

	A Дрожжи	B Содержание витаминов, мкг, на 1 г абс. сухих дрожжей					
		1 рибофлавина	2 пиридоксина	3 пантотеновой кислоты	4 никотиновой кислоты	5 холина	6 биотина
a	Бирюсинские	125,4	11,5	41,3	554,1	3908	0,86
b	Красноярские	127,1	13,6	30,4	464,6	2740	0,82
c	Лобвинские	121,1	18,6	46,3	540,5	4349	2,33
d	Тавдинские (из барды)	86,2	11,3	64,7	548,8	4553	1,29
e	Тавдинские (из гидролизата)	98,0	14,1	70,9	453,4	3493	1,16
f	Выборгские (февраль 1959 г.)	73,9	13,3	9,3	429,6	3279	0,97
g	Выборгские (ноябрь 1959 г.)	39,5	8,8	4,5	415,0	4065	0,66
h	Выборгские (ноябрь 1959 г.), обогащенные витамином B_{12}	43,2	15,5	7,1	556,0	4299	0,81

Key: A - Yeasts B - Content of vitamins, in micrograms, per gram of absolutely dry yeasts
1 - Riboflavin 2 - Pyridoxine 3 - Pantothenic acid 4 - Nicotinic acid 5 - Choline 6 - Biotin
a - Biryusinskiy b - Krasnoyarskiy c - Lobvinskiy d - Tandinskiy (from mash) e - Tandinskiy (from hydrolyzate) f - Vyborgskiy (Feb 59) g - Vyborgskiy (Nov 59) H - Vyborgskiy (Nov 59) enriched with vitamin B_{12}

is carried out on vacuum filters under production conditions, where the yeast suspension after separation can be brought to the state of a paste containing 20-22% of dry matter. The pressed yeast biomass is plasmolyzed with hot water or low-pressure steam. During thermal plasmolysis the membrane of the yeast cell is destroyed and the plasma contained in it flows out. Therefore the pressed and later plasmolyzed biomass becomes liquefied instead of pasty. The method of yeast filtration was used in the initial period of development of fodder yeast production, and also when there was a shortage of separators. Because of its relatively low effectivenss, filtration is hardly used at all now. The next process -- drying of the yeast -- is similar to drying in other equipment. All the rest are combinations of the above-described methods of dehydration.

2174
CSO: 8344/1857

UDC: 575.191:001.1

GENETICS OF MICROORGANISMS AND MEDICINE

Moscow ZHURNAL OBSHCHEY BIOLOGII in Russian No 3, 1978 pp 335-346

[Article* by V. D. Timakov (deceased), Institute of Epidemiology and Microbiology imeni N. F. Gamaleya, USSR Academy of Medical Sciences, Moscow, submitted 2 Nov 77]

[Text] Medical aspects of genetic research pursued on microorganisms are discussed. Data are submitted on genetic control of virulence and toxic production of bacteria. Genetic and biochemical research dealing with catabolite repression and mechanisms of repair of DNA injuries induced by radiation and chemical agents are analyzed. There is discussion of the role of genetics of microorganisms in development of general genetics and formation of the new molecular genetics direction in biology.

The author formulates the objectives of research on genetics of microorganisms of basic importance to both medicine and learning general biological laws.

As we know, research in the field of genetics of microorganisms played an outstanding role in development of genetics as a whole. This is due, primarily, to the fact that genetic investigation of microorganisms was pursued not only to solve microbiological, but general biological problems.

Research on genetics of microorganisms made it possible to demonstrate the genetic role of DNA, determine the material basis of the gene and its complex structure, decode the genetic code and solve the main problems of mutagenesis. It laid the foundation for molecular biology and molecular genetics. At the present time, microorganisms are still the most important experimental model for the study of general biological genetic problems that have a bearing on diverse aspects of the natural sciences.

*Paper delivered to the All-Union Society of Geneticists and Breeders imeni N. I. Vavilov (Leningrad, May 1977).

Research in the field of genetics of microorganisms is of exceptional importance as well to numerous branches of medicine, in particular for the control of infectious diseases, to solve problems of carcinogenesis, hereditary diseases, radiation lesions and several others. These studies make it possible to understand the mechanisms that determine onset and development of infectious diseases, the patterns of processes of recovery and development of immunity. Genetic studies make it possible, finally, to determine the significance of genetically determined functions of microorganisms and structures thereof, which are responsible for pathology of the infected macroorganism and immunity; they are of enormous significance in diagnostics of infectious diseases, development of scientific principles and means of specific prevention and therapy thereof. For this reason, it is quite understandable that research in the field of genetics of microorganisms has always been and still is in the center of attention of microbiologists, from the time microbiology emerged as an independent science. This applies in particular to those concerned with pathogenic microorganisms, the pathogens of terrible epidemic infections that carried millions of human lives to their graves, infections that, even in our times, are of first and foremost significance in the structure of morbidity and mortality, that are very detrimental to human health and the economy.

The earliest research in the field of genetics of microorganisms is unquestionably referable to the ingenious L. Pasteur. He was the first to show that one can alter hereditary properties, under the influence of various factors, of such highly pathogenic microbes as the pathogen of fowl cholera, anthrax and rabies, that one could deprive them of the capacity to induce disease and retain their useful properties, the capacity to induce immunity.

True, neither Pasteur nor his followers used genetic terminology, but the genetic essence of their research is unquestionable.

The studies of Pasteur, dealing with development of vaccine strains and use thereof to prevent anthrax, fowl cholera and rabies, were enormously beneficial to mankind and drew the attention not only of microbiologists, but numerous representatives of other specialties working in the field of the natural sciences.

As a result of this research, vaccine strains were obtained of the pathogens of plague, tularemia, tuberculosis, brucellosis, rickketsiosis, polio and measles. However, the vaccine strains of the pathogens of plague, brucellosis, rickettsiosis and measles were not obtained as a result of specific treatment of microbes; rather, they were isolated as attenuated strains directly from their habitat, in particular, directly from the patient's body. In other words, these strains were created by nature itself, and not the hands of the experimenter.

No doubt, this situation was a reflection of the fact that the true causes determining molecular genetic patterns causing virulence and immunogenic properties of microbes had not been discovered. Unfortunately, even now, only

slight knowledge about them has been obtained. This is why problems of genetics of virulence and immunogenic properties of microbes, problems of laying the scientific foundation of attenuation are first and foremost.

At the present time, some data have already been accumulated, characterizing the genetic bases of virulence and antigenic structure of some pathogenic bacteria. We refer to genetic control of synthesis of salmonella and shigella antigens, evaluation of their role in bacterial virulence, identification of some sites on the bacterial chromosome that implement their pathogenic action. This research was initiated by studies of salmonella, which revealed the genetic essence of the dissociation phenomenon, i.e., the change from S to R forms of bacteria, associated with loss of virulence. The existence of three main regions was demonstrated on the salmonella chromosome, which determine synthesis of O antigen responsible for endotoxic and antigenic properties of salmonella. It was found that one site is responsible for synthesis of sugars of the R nucleus of lipopolysaccharide, another controls synthesis of its S-specific chains and the third determines synthesis of polymerases involved in elongation of side chains and polymerization thereof (Stocker, Makela, 1971). It was shown that the greatest loss of virulence, related to loss of antiphagocytic activity, is observed with total loss of S-specific side chains. Mutants deficient in synthesis of R-nucleus sugars are less virulent than mutants deficient in polymerase synthesis (Roantree, 1971). Thus, these data are indicative of the significance of presence of polysaccharides of salmonellar O antigen and amount of polysaccharide chains to their virulence.

The use of genetic mapping methods (conjugation and transduction) made it possible to also assess the significance of the chemistry of a polysaccharide to virulence of salmonella with respect to a specific host, i.e., to discover the correlation between the structure of lipopolysaccharide macromolecules and species-specific sensitivity of the host.

At the present time, the genes responsible for synthesis of Vi antigen, which is important to virulence of typhoid bacteria, have been mapped. It was shown that synthesis thereof is determined by two sites, Vi-A and Vi-B that are far from one another on the chromosome (Johnson et al., 1965).

The obtained data can be used for practical purposes. Thus, studies are in progress of the immunological value of different R mutants of salmonella. An S. typhimurium strain has been constructed with an antigenic structure replaced by the structure of typhoid bacteria. Unlike S. typhi, this strain induces genuine infection in mice given small doses, which makes it possible to use it in laboratory evaluation of the efficacy of typhoid vaccines.

An effort is being made to develop synthetic products for the prevention of salmonellosis, which consist of immunodeterminant groups of sugars of O-antigen lipopolysaccharide, combined with S albumin and adjuvant (Staub, LeBuc, 1975).

Important results were obtained from studies of genetic control of virulence of Shigella flexneri dysentery bacteria (Timakov, Petrovskaya, 1972; Petrovskaya, 1973). At the present time, genetic control of synthesis of O-antigen polysaccharide of these bacteria has been largely identified.

Thus, genetic studies pursued in our department revealed that the polysaccharide of O antigen of S. flexneri of all serotypes is based on group-specific antigen 3,4 that is determined by a chromosomal gene. All other group- and type-specific components of O antigen of S. flexneri are the result of modification of this main structure and are determined by the appropriate convertant phages (Timakov et al., 1970; Petrovskaya, Bondarenko, 1971; Timakov et al., 1972; Bondarenko, Petrovskaya, 1976). These studies made it possible to decode the mechanisms of so-called type changes in shigella, as well as to plot a chart that permits differentiation, in the case of type change under natural conditions, between genetic instability of strains and super- or mixed infection, and to make corrections in the classification of S. flexneri on a genetic basis (Petrovskaya et al., 1977).

Investigation of the process of interaction between the microorganisms and stricken organs and tissues of the macroorganism is quite important to demonstration of virulence factors of microorganisms. In the department headed by Prof M. V. Voyno-Yasenetskiy, an electron microscopic study of interaction between dysentery bacteria and intestinal epithelial cells revealed that the first stage is firm attachment of shigella to the epithelium, followed by penetration into the cell.

In our department, studies of shigella of the wild type, mutants and hybrids obtained by crossing shigella with E. coli revealed that the lipopolysaccharide of S. flexneri O antigen is involved in the first stage of attachment of shigella to the epithelium, although it does not cause them to penetrate into the cell (Bondarenko et al., 1976).

As for the process of penetration of the pathogen of dysentery into the epithelium, it is implemented by a special factor, the nature of which has not yet been definitively established. It was demonstrated that the capacity in shigella of penetrating into epithelial cells is determined by the so-called KcpA gene (Formal et al., 1971; Bondarenko et al., 1973). Recently, mutation glpK has been mapped; it affects the capacity of dysentery bacteria to strike HeLa cells (Kim, Corwin, 1974). Morphological studies of the bronchial epithelium of mice infected intranasally with KcpA$^-$ and glpK$^-$ strains of S. flexneri established that the latter lose, in addition to penetrant activity, the capacity to influence development of the leukocytic reaction and exert a deleterious effect on vessels (Dragunskaya et al., 1977). The products of the above genes are not known.

Nevertheless, a biolotically active factor was discovered in our department, which is isolated from the virulent strain and absent in avirulant mutants and hybrids of the smooth type (Mirolyubova, Petrovskaya, 1977). The results warrant the belief that this factor is a protein or derivative thereof

(Mirolyubova et al., 1977). It was also shown that secondary specific side chains of S. flexneri O antigen do not play a significant role in interaction between the bacteria and epithelium, but impart to them great resistance to humoral (Blinova, 1973) and cellular (Bondarenko et al., 1975) factors of protection of the macroorganism. V. M. Bondarenko mapped the determinant of S. flexneri cytotoxin, which has a lethal effect on macrophages that is more often induced by virulent, freshly isolated strains of the pathogen (Bondarenko, Maslova, 1975).

Thus, a number of factors have been identified in S. flexneri, which determine its capacity to induce the disease.

This research is of exceptional importance to demonstration of the early stages of onset of the infectious process and, at the same time, they open the way for development of preventive agents capable of blocking the infectious process at its early stages. Evidently, the principles of research applied to the study of salmonella and shigella can be used as well in the study of pathogens of other infectious diseases.

In such a quite important and, essentially new area as genetics of bacterial virulence, consideration of genetic aspects of toxin production merits special attention. Genetic studies of toxinogenesis yield important information about processes of regulation of toxin synthesis in the cell, metabolic role of toxins, correlation between their chemical structure and biological activity, the role of toxins as pathogenicity factors. Investigation of genetic aspects of toxinogenesis is based on the thesis that the bacterial capacity to produce toxin is an inherited property, and that this property is subject to change as a result of mutations.

Here, we should stress the great difficulties involved in the study of genetics of toxinogenesis in bacteria, which are related to isolation of mutants with altered toxigenicity. With regard to most of the toxigenic bacterial systems studied, there are still no techniques that permit creation of selective conditions for mutant selection. Nevertheless, the situation does not appear to be entirely hopeless. At the present time, researchers have a number of very active mutagenic agents capable of increasing the incidence of bacterial mutations by hundreds and thousands of times. This opens the way for isolation of mutants with altered toxigenicity, even without using special selective procedures. If there are experimental animals that are sensitive to toxins, it is possible to demonstrate nontoxigenic mutants by means of comparison to the toxigenicity of the original parental strains.

Demonstration of bacterial protein exotoxins is largely based on their biological activity in the microorganism, their serological specificity or, in some cases, their enzymatic activity. The use of immunological tests makes it possible to demonstrate production of nontoxic protein, immunologically related to toxin, by nontoxigenic mutants. Such mutations are also of great interest because they reveal correlations brtween protein structure, biological activity and antigenic properties of bacterial toxins.

Complementation analysis and mapping, like other branches of genetics, are effective techniques that permit identification of mutations that affect toxin synthesis as referable to one or different cistrons and localization of the genes controlling this process.

The successful development of genetics of microorganisms in the last few years offered convincing evidence of the fact that the genes determining toxin synthesis may be localized in the genomes of specific bacteriophages in some cases, in the plasmids in others, and on the chromosome of the bacterial cell proper in other cases yet, in different species of toxigenic bacteria.

Processes of determination of toxin production in the pathogen of diphtheria have been submitted to the most comprehensive investigation. The structural genes of toxin synthesis have already been precisely mapped for the toxigenicity-converting phage of the pathogen of diphtheria, among 15 identified cistrons. Recently, methods were developed for intracistron mapping of the gene of toxin synthesis in phage, using mutants that control synthesis of aminoterminal fragments of diphtheria toxin varying in molecular weight. Even the orientation of transcription of the gene of toxin synthesis has been determined. Decoding the genetic mechanisms of regulation of synthesis of diphtheria toxin in the cell is a considerably more complex matter. At the present time, a hypothesis has been expounded, according to which the genome of the diphtheria bacteria codes synthesis of a repressor which, combined with an iron ion as a corepressor, interactions with the operon in the genome of the toxigenicity-converting phage and blocks expression of the phage structural gene of toxin production. According to this model, there should be both repressor-negative bacterial mutants and operator-constitutive mutants of converting phages (Murphy et al., 1974). The future will show whether this hypothesis is valid.

Genetic determination of toxin synthesis by plasmids is common in enteropathogenic bacteria. The enterotoxigenic colibacilli produce two classes of toxins, thermostable and thermolabile. The thermolabile enterotoxins consist of proteins immunologically related to cholera enterotoxin, with similar mechanism of action, and they are determined by plasmids. Thus far, no mutations have been detected in these plasmids that would affect the production of toxins. Genetic studies of toxin production in enteropathogenic bacteria are concentrated on molecular structure of these plasmids. It was shown that their molecular weight is about $60 \cdot 10^6$ dalton, and that they contain about 50% GC pairs. Using methods of gene engineering, So et al. (1975) excised a segment of genetic information from the plasmid of annenteropathogenic colibacillus, determining synthesis of thermostable toxin and they inserted it into a small plasmid that determines cell resistance to tetracycline. As a result, they obtained a hybrid plasmid, which they designated as B12-1, in which the genes for toxin synthesis constituted 10-20% of the plasmid. The hybrid plasmid was found to be 10 times richer in genes of enterotoxin synthesis than the original natural plasmid. These studies open the way for cloning specific enterotoxin genes, obtaining many copies of the gene and its product, toxin. This approach to the study of the structure

of these genes and mechanisms of regulation of their activity offers some opportunities for solving a number of problems of genetics of microorganisms.

As we have already mentioned, the thermolabile enterotoxin of E. coli is similar in its antigenic properties to the thermolabile enterotoxin of Vibrio cholerae, but the structural gene of the latter is localized on the vibrio chromosome, rather than the plasmid. In the laboratory of Holmes (Holmes et al., 1975), a technique was developed for isolating nontoxigenic mutants of V. cholerae, and the genes determining synthesis of cholera enterotoxin were mapped. It was established that this gene is closely linked with the gene of histidine biosynthesis in the first linkage group of V. cholerae. Moreover, we already know the relative position of the toxigenicity gene, in relation to all other genes in this group. Along with great theoretical interest with respect to comprehension of the nature of genetic determination of toxigenicity of bacteria, this research is also important to the development of vaccines. One of the avirulent mutants of V. cholerae obtained by Holmes, which is absolutely harmless when ingested by mouth by volunteers, even in large doses, prevented contraction of cholera upon subsequent infection with a homologous toxigenic and virulent strain of V. cholerae. These findings are indicative of the possibility of using avirulent mutants of V. cholerae as effective oral vaccines.

Little is known about the localization of genes of toxin production in other pathogenic bacteria. But, apparently even in closely related bacterial species, the genes controlling toxin synthesis may be located in different genetic structures of the cell. The studies of Il'yashenko et al. indicate that the genes of toxin production of different types of pathogens of botulism may be contained both in the genome of converting phage and other plasmid elements of bacteria (Perova et al., 1975).

To sum up the foregoing, it may be stated that genetic investigation of the phenomenon of toxin production by bacteria is still at its first stage. Nevertheless, even now we have diverse information about the possible localization of genes of toxin synthesis in different known genetic elements of the cell. Development of this problem will be very important in gaining knowledge about the basic biological mechanisms of microbial toxinogenesis, pathogenesis of infections, as well as in finding new and effective means of antitoxic immunization.

With reference to the importance of genetic data characterizing pathogenic bacteria, we should dwell specially on questions pertaining to bacterial plasmids, the study of which has now acquired much importance in various branches of molecular genetics and microbiology. It is common knowledge that they play the role of factors of conjugative transfer of genetic material; they serve as models for the study of mechanisms of DNA replication and regulation of gene functions, as vector molecules that are used in gene engineering research. However, this does not exhaust the importance of plasmids. The sum total of information available to date is indicative of the important role of bacterial plasmids in infectious pathology (Likhoded,

Tabachnik, 1977). This role is determined by the capacity, demonstrated in plasmids, of imparting drug resistance, virulence and toxigenicity to microorganisms. It is a known fact that that bacterial strains carrying p smids of drug resistance (R factors) are extremely widespread at the present time. They are found in the environment, animals and people who were or were not treated with antibiotics. The wide, often uncontrolled and unreasonable use of antibiotics in medicine and veterinary practice creates beneficial conditions for selection of such strains. This is associated with formation of permanent reservoirs of strains with R factors. Strains that were bred as a result of unreasonable use of antibiotics at livestock farms and treatment of the sick are better able to survive in the intestine and have stronger virulent properties. This circumstance should make us very cautious. The significance of this phenomenon to epidemiological and infectious practice requires a substantial revision of existing methods of using antibiotics and, in particular, settling the question of desirability of use thereof in agriculture.

Present conceptions of the mechanisms of spread of drug resistance are based on data pertaining to R plasmid transmission among different species, genera and even families of bacteria, as well as among bacteria referable to the same species (Reanney, 1976). In recent years, an extremely interesting finding was made, concerning the incidence of drug resistance referable to plasmids. We refer to the capacity for migration inherent in a number of genes contained in R plasmids determining drug resistance. In this case, migration refers to the passage of genes from one plasmid to another, from a plasmid to a chromosome, or shifting within the same replicon. Migrating genes were named trasposons (Hedges, Jacob, 1974). Genes that determine resistance to ampicillin, chloramphenicol, tetracycline, kanamycin and trimethoprim with streptomycin (Cohen, 1976; Smirnov, Il'ins, 1977).are referable to the transposon class. The chief properties of transposons are: 1) high incidence of excision from original structures and insertion in new genetic structures; 2) low specificity of inclusion, i.e., capacity for migration among nonhomologous, unrelated genomes, and 3) migration is independent of the function of known cellular recombination systems. It is assumed that the capacity for migration is determined in transposons by the fact that the genes they contain are surrounded by genetic structures of a special class, which were named insertion sequences or IS elements.

The most important property of transposons in clinical medicine is their capacity to migrate among nonhomologous genetic structures, not only of the same bacterial species but bacteria of remote genera and families. This means that the transposons determining drug resistance may migrate from plasmids inherent in nonpathogenic or conditionally pathogenic bacteria to plasmids with a broader spectrum of action, and they are capable of penetrating into the cells of pathogens of infectious diseases, for example, Haemophillus influenzae type B, which induces meningitis and other serious infectious complications (DeGraaff et al., 1976).

Another very important circumstance is that migration of plasmid drug resistance occurs not only in laboratories but under natural conditions. The problem of bacterial drug resistance is already a rather serious one in its national economic implications. There are serious grounds to believe that this problem may become even more acute in the next few years.

Plasmid control of features used to identify bacteria in laboratory diagnostics also plays an important role. For example, plasmids have been detected in salmonella and other enterobacteria, which determine fermentation of lactose and saccharose. The existence of plasmids of this type could lead to formation of atypical strains and present considerable difficulties in bacteriological diagnostics (LeMinor et al., 1973; Johnson et al., 1976; Petrovskaya et al., 1977).

In recent years, much attention has been devoted to plasmids that control pathogenicity and virulence of bacteria. Among enterobacteria, this refers to Hly plasmids that determine synthesis of hemolysin, Ent plasmids that determine synthesis of enterotoxin, colicinogenic factor ColV and certain K plasmids that determine synthesis of superficial fimbrioid structures.

The most vivid example of the role of plasmids in bacterial pathogenicity is referable to the data obtained by numerous authors from studies of enterotoxigenic strains of E. coli and other enterobacteria. It was established that many strains of Escherichia carry the Ent plasmid, which determines synthesis of enterotoxin, the antigenic specificity and mechanism of action of which are virtually the same as in cholerogen. Such strains induce diarrhea in animals and man, including cholera-like diseases and so-called travelers' diarrhea. Cooperation of two plasmids may play an important role here, for example, between enterotoxigenic plasmid Ent and one of the K plasmids that impart to bacterial cells the capacity to multiply in the small intestine. As shown by Smith, transmission of the enteropathogenic plasmid and plasmid K88 imparts the capacity to induce fatal diarrhea in piglets to the well-known laboratory strain K12 of E. coli in the R form (Smith, Linggood, 1971). The same author demonstrated that, in the presence of colicinogenic factor ColV, Escherichia cells acquire the capacity to multiply in viscera and induce septicemia (Smith, 1974).

Thus, it was now been clearly established that some plasmids can change conditionally pathogenic bacteria into pathogenic ones. Of basic importance is the fact that not only plasmids of pathogenicity, but various R factors are often demonstrable concurrently in bacterial cells. In selecting strains for R factors, as a result of using antibiotics there is also automatic selection of strains carrying pathogenicity plasmids. As a rule, the transfer of R factors is also associated with transfer of other plasmids. All this must inevitably lead to the spread of pathogenicity plasmids. This is probably one of the explanations of the fact that, in recent years, conditionally pathogenic bacteria have begun to play an important role in infectious pathology.

It must be noted that plasmid control of bacterial pathogenicity has been very little studied thus far. This aspect of function of many plasmids has not been investigated at all. This is largely attributable to the lack of convenient models for the study of virulence of conditionally pathogenic bacteria.

The study of the role of bacterial plasmids in infectious pathology is also being hampered by the lack of convenient methods of bacteriological diagnostics accessible to clinical laboratories. Unfortunately, only biochemical and serological methods are used at the present time for identification of conditionally pathogenic bacteria. Convenient methods of demonstrating enterotoxigenic and other strains carrying pathogenicity plasmids have not yet been developed for broad use. Development of such methods is a pressing task for microbiology.

It is also obvious that there is a need to investigate the incidence of R factors and other plasmids among pathogenic and conditionally pathogenic bacteria, as well as to assess their role in infectious pathology. Unquestionably, investigation of plasmid control of pathogenicity will open the way for development of immunotherapeutic agents that are needed for the treatment of diseases induced by conditionally pathogenic bacteria that are resistant to a number of antibiotics and other drugs.

The material discussed above characterizes the genetic bases of pathogenic action of bacteria. The medical significance of genetic microbiological research is not limited to the study of these bases. It is definitely important for clinical medicine to know the mechanisms of pathogenic action of microorganisms, i.e., to have an idea about factors of virulence, pathogenicity and drug resistance in bacteria. However, it is equally important to know about the genetic mechanisms that determine changes in these factors, transfer thereof from some bacteria to others, mechanisms at the basis of function of genetic determinants and regulation of their activity. The wide front of basic genetic and molecular biological research, which is being conducted on bacteria and viruses, must be recognized as being medically important for expressly this reason.

Research on mechanisms of regulation of gene activity, which is being conducted in our department, is referable to the area of regulation of carbohydrate transport into the bacterial cell. In particular, some basic research has been done on the function of the phosphoenolpyruvate-dependent phosphotransferase system (PTS) in E. coli. Methods were developed for isolation of mutants with loss of one or several PTS components. Genetic and biochemical investigation thereof established that PTS proteins are involved in the transport of many carbohydrates into the bacterial cell (Gershanovich, 1973). In addition, it was shown that mutation injury to common PTS components (pts mutation) leads to depression of the rate of synthesis of catabolite-sensitive enzymes (Gershanovich et al., 1970). A more comprehensive study revealed that pts mutations depress synthesis of inducible proteins at the transcription stage (Bol'shakova et al., 1976), and the hypothesis was

expounded that the products of pts genes play the role of positive effectors in regulating transcription of catabolite-sensitive operons (Gershanovitch et al., 1977).

Discovery of the role of PTS in the transport of glucose and analogues thereof in E. coli made it possible to demonstrate that the phenomenon of catabolite repression of synthesis of catabolite-sensitive enzymes occurs as a result of interaction between glucose and transport proteins (Bourd et al., 1975). A change in properties of these proteins in pts mutants renders pts bacteria resistant to catabolite repression (Gershanovich et al., 1970). A new type of mutation (tgl) was isolated and mapped; it induces resistance to catabolite repression by glucose (Bourd et al., 1975). Unlike pts mutations, injuries in the tgl locus do not affect the rate of glucose metabolism. Theoretical research dealing with PTS in the physiology of E. coli yielded a practical application: Bacterial and yeast strains producing commerically important enzymes, resistant to catabolite repression, were obtained (Gershanovitch et al., 1977).

Speaking of genetic microbiological research, it should be stressed that it has not only medical, but general biological significance. The medical implications of studying genetic mechanisms go far beyond the framework of purely microbiological problems. In this case, microorganisms are experimental models, i.e., objects of analysis aimed not only on identifying the distinctions inherent in the pathogens of infectious diseases, but conducted for the purpose of studying general biological genetic patterns, including those that are important from the standpoint of such medically important problems as carcinogenesis, radiation lesions, hereditary diseases, etc.

Research on the mechanisms of mutagenesis is making a large contribution to development of these problems. As we know, the mutational variability of microorganisms is being studied on a rather broad scale. Some substantive results have been obtained in this area of research. This problem acquried several new aspects in the last few years; in particular, work dealing with investigation of the mechanisms of mutagenesis is being closely tied in with the study of bacterial enzymatic systems, the functions of which are implemented by integrity of genetic material. These enzymatic systems were first discovered (Setlow, Carrier, 1964) in studies with bacteria, which are still the main objects for studies of mechanisms of DNA injury and patterns of repair thereof. This research is acquiring special importance in the medical aspect. It was found that the patterns of repair of DNA injuries in bacteria are inherent in mammalian cells, including human cells. At the same time, it was learned that hereditary impairment of repair processes in cells of the human body leads to such serious diseases as xeroderma pigmentosum, which is due to the inability of skin fibroblasts to repair DNA lesions induced by ultraviolet light or x-rays. In addition to xeroderma pigmentosum, Bloom's syndrome, Fanconi's anemia, progeria and certain other extremely serious diseases are among diseases related to impaired capacity for repair of DNA injuries (Howard-Flanders, 1973).

For the last decade, genetic and biochemical studies have been pursued in our department, which deal with the molecular genetic mechanisms of repair and involvement of repair processes in bacterial mutagenesis.

In the course of these studies, determination was made of the range of action of products of genes that determine the first stage of excision repair (Timakov, Skavronskaya, 1969), the fine genetic patterns have been discovered, which are indicative of a link between replicative, repair and recombination processes inherent in bacterial cells (Smirnov et al., 1973b; Sayenko et al., 1974). As a result of investigations of E. coli and salmone l , several genes determining the bacterial capacity to repair DNA injuries induced by radiation and chemical agents were discovered, mapped and studied (Andreyeva et al., 1972a, b; Skavronskaya et al., 1973a; Skavronskaya et al., 1973b, c, 1974). It was established that there may be impairment of repair of DNA injuries induced by chemical agents, occurring after incorporation of 5-bromouracil in DNA (Kondrat'yev, Skavronskaya, 1972a, b). Investigation of the effects of alkylating chemical agents on repair mutants made it possible to describe DNA injuries occurring under the influence of these agents and to define the nature of mutations induced by them (Smirnov et al., 1973a, b; Skavronskaya, Smirnov, 1975).

Investigation of the patterns of bacterial mutagenesis induced by ultraviolet light made it possible to assess the functions of a number of genes in onset of mutations (Skavronskaya et al., 1973a; Skavronskaya et al., 1973b; Aleshkin, Skavronskaya, 1973).

Research conducted in the last few years (Skavronskaya et al., 1977) yielded a rather remarkable finding: Salmonella is capable of mutating under the influence of ultraviolet light only if it contains colI or R plasmids. The presence of these plasmids also gives salmonella the normal capacity for excision repair. This capacity is diminished in salmonella containing no colI or R plasmids.

The data indicative of development of sensitivity to the mutagenic effect of ultraviolet light due to the presence of plasmids open up new prospects for the study of the still unanswered question of bacterial mutagenesis.

The results of studies dealing with patterns of bacteria mutagenesis have wide applications in the problem of a safe environment for man. Specially developed mutants of salmonella and E. coli, with high sensitivity to the lethal and mutagenic effects of chemical mutagens, are used to detect substances that are potentially hazardous to man. These mutants are used for preliminary screening of mutagenic (potentially carcinogenic) agents in man's environment. The use of the mutagenic effect as an index of potential carcinogenicity of chemical or other agents is based on establishment of a close correlation between mutagenic and carcinogenic effects. The use of bacterial tests, along with activation of procarcinogens, made it possible to demonstrate a significantly greater correlation, than previously believed, between the mutagenic and carcinogenic effects of chemical and physical

agents, and to demonstrate finer mechanisms of their carcinogenic action. The use of bacterial objects is important not only in screening carcinogenic and mutagenic substances; they unquestionably have a bearing on learning about the very essence of carcinogenesis.

In conclusion, it should be stressed that the data pertaining to identification of genetic patterns are of definite theoretical and practical importance with respect to learning about the specific distinctions of the genetic system of pathogenic bacteria. They also open up the realistic prospect of controlling vital functions of pathogenic microorganisms and gaining knowledge about the molecular bases of pathogenic action and pathogenesis of infectious diseases at the very earliest stages of onset of a pathological process. The information obtained warrants the belief that, at the present time, there is an urgent need to use data on genetic exchange, which has been studied the most comprehensively in E. coli and other nonpathogenic microorganisms, for investigation of genetics of pathogenic bacteria, as well as demonstration of all specific physiological and genetic distinctions inherent in these microorganisms.

This transition cannot be construed as a mere change of objects to be investigated. There is an imperative need for it for the control of infectious diseases, development of reliable methods for earlier detection thereof, more effective means of treatment and prevention.

In addition, we should like to stress once more that research in the field of genetics of microorganisms played an extremely important role in development of general direction and formation of a new direction in biology, the molecular genetic aspect of this discipline. It is unquestionable that future research in this field will add more than one new page to revelation of the mysteries of nature and the very essence of life.

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CSO: 1870

UDC: 575.001.1

SOME PRESSING PROBLEMS OF GENETICS

Moscow ZHURNAL OBSHCHEY BIOLOGII in Russian No 3, 1978 pp 347-356

[Article* by N. P. Dubinin, Institute of General Genetics, USSR Academy of Sciences, Moscow, submitted 1 Aug 77]

[Text] This article deals with pressing problems of modern genetics: the role of genetics in mobilizing food and raw material resources, genetics and medicine, the problem of environmental mutagens, social and biological aspects of the problem of man, genetic engineering. These are the directions pursued in the main work dealing with basic genetics. The author has summarized the main advances and formulated the tasks confronting these scientific directions.

Our times are characterized by profound ties between natural and social sciences. This is understandable, since science is becoming increasingly responsible for the welfare and development of society under socialism. Public practice advances new problems, the development of which requires the cooperation of a number of disciplines. This is manifested the most vividly in the need for ecologization of industry and agriculture, for the solution of both industrial problems and those referable to providing the appropriate environment for man. To solve such problems, the disciplines subject to integration must be ready for them and society must be capable of so doing. In this respect, the advantages of socialism are inestimable. Finaly,, theoretical disciplines play a substantive role, as they take on the leading role in the combination of natural and social sciences. We refer to philosophy, sociology and the natural sciences that are acquiring a key position in the area of studying nature. At the present time, these disciplines are the leaders of natural sciences, and the example of physics illustrates well the socioscientific position of this leader. Physics has penetrated deep into the nature of the micro- and macro-world; its data serve for active, creative development of dialectical materialism, creation of a modern scientific outlook of the world; it has becoming the leading force of scientific and technological progress, without which modern civilization and affirmation of socialism would be impossible.

*Text of paper delivered at the Third Congress of the All-Union Society of Geneticists and Breeders imeni N. I. Vavilov (May 1977, Leningrad).

Such a situation is also occurring in biology: genetics holds the key position in the entire science of life. We must describe carefully the set of problems that is beginning to profoundly link the social life of mankind with advances in genetics. This will enable us to outline the main strategic objectives of our science, purposeful work on which will constitute an appreciable part of its development.

Contribution of Genetics to Solving Problems of Food and Raw Material Resources

The profusion of products and raw material depends largely on the advances of genetics in agriculture and the biological industry.

Development of breeding has reached a high level in our country. At first, general knowledge of the laws of heredity and variability was applied to serve breeding, and the leader of this stage was N. I. Vavilov, who elaborated the ecological and geographic principles of breeding and the law of homologous orders of hereditary variability. The worldwide collection assembled at the All-Union Institute of Plant Growing had a profound effect on Soviet breeding work. Problems of remote hybridization were solved through the work of I. V. Michurin, N. V. Tsitsin, G. D. Karpechenko and others. Some remarkable advances were made in breeding, thanks to the achievements in general genetics. This is indicated by the work of A. P. Shekhurdin, V. S. Pustovoyt, P. P. Luk'yanenko, N. V. Remeslo, F. G. Kirichenko, P. F. Garkavyy and A. V. Mazlumov, dealing with wheat, sunflowers, barley, sugar beets, corn and others. The use of special methodological work in genetics had a strong influence on breeding, and in this reference we should mention the work of M. I. Khadzhinov dealing with controlled heterosis in corn, V. A. Panin, A. N. Lutkov and V. P. Zosimovich dealing with polyploid sugar beets, G. A. Nadson, A. A. Sapegin, L. N. Delone and I. A. Rapoport on the use of radiation and chemical mutagens in breeding microorganisms and plants, V. A. Strunnikov on the use of structural and other mutations in breeding silkworms.

Induced mutations not only make it possible to improve individual characters, but to develop new properties. The radiation mutant of P. K. Shkvarnikov and I. V. Chernyy served as the basis for developing Novosibirskaya 67 variety of spring wheat. The alkaloid-free lupine of V. I. Golovchenko resulted in appearance of a new variant of this plant. The question of creating winter-hardiness genes in winter wheat is being raised. A. F. Shulyndin, who used amphidiploid hybrids of wheat and rye, developed promising forms of a new grain plant, triticale. N. A. Lebedeva, who combined experimental polyploidy with remote hybridization, developed a new method of potato breeding. In a number of these works, we already find elements of the breeding stage that is characterized by the fact that logically designed models of strains, varieties and breeds are being brought to life as a result of the purposeful use of the set of genetic and breeding methods.

Models of sets of characters that intensified varieties and breeds were developed on the basis of genetic and physiological approaches. Development of special genetics, biochemistry and physiology of each of the objects of breeding was of enormous importance to the solution of these problems. An

example is found in the book of A. A. Zhuchenko concerning special genetics of tomatoes. Among the new breeds of livestock, the Tadzhikskaya breed of sheep, developed by G. A. Aliyev, is promising.

On the whole, in our times, breeding is faced with tasks that surmount all that was accomplished in 20,000 years of agriculture and animal raising. On the average, it is imperative to increase by 3-4 times the productivity of each hectare of tilled land, meadows, pasturage, fruit and berry plantings and forests. To fulfill these tasks, it is imperative to implement purposeful genetic and breeding projects for all agricultural crops, pasture grasses,and trees, each of which must resolve a distinctly formulated problem on the regional or national scale, in accordance with the plans for socialist countries and, in some cases, on a worldwide scale. Problems of quality of foodstuffs and raw material, yield and productivity, improvement of such characters as immunity to diseases, nonlodging of wheat, rye, rice and other crops, hardiness in wheat, resistance to wilt and defoliation of cotton, yield of sugar per hectare from sugar beets, disease resistance in potatoes, multiple ears in corn, early maturation and quality of wood pulp, etc., are acquiring much importance.

It is to be expected that very soon genetic breeding will experience the transforming influence of the advances in genetic engineering. At first, the methods of genetic engineering will transform breeding of microorganisms used in the biological industry. Then will come the turn of plant growing and livestock raising. It is known that, on our planet, plants remove 110 million tons of nitrogen from soil each year. The bases of agrochemistry will change with transmission to plants of the capacity for nitrogen fixing. If, moreover, there is a qualitative reconstruction of protein in grain with the required amino acids, man will depend less on animal protein.

At the present time, the solar energy that hits earth is used for the production of food and raw materials on only 12% of the surface of land. We are coming into an era of genetic and breeding intervention in life that develops in the seas and oceans. It is believed that the marine organisms that are rich in protein required by man and and carbohydrates can build up the food resources by 400%. The responsibility of scientists who will develop plans for genetic and ecological intervention in life over the enormous expanses of water on our planet is obvious.

Work dealing with genetics and breeding to increase the volume and improve the quality of food and raw material is of paramount importance to the solution of basic social problems. Genetic breeding is the cheapest method of intensifhing agriculture and the microbiological industry. Based on the advantages of socialism, genetic breeding of plants will yield forms with high qualities, productivity and resistance to diseases; and in the future it will yield plants capable of fixing nitrogen. After development of cloning, superovulation, sex regulation and other methods, genetics of farm animals will eliminate agriculture's increasing need for energy and enormous expenditures on chemical fertilizers and chemical protective agents. All this will provide for an abundance of cheap products and raw material, available to all peoples of the world under socialism.

Genetics -- the Foundation of Medicine

For a long time, the role of genetics in medicine was considered in the light of etiology and treatment of hereditary diseases. Nowadays, this direction, based on the teaching on the genetic burden in human populations, has acquired even more importance. A total of 2100 mutant genes have been discovered that impair the development of man. Analysis of molecular, biochemical and chromosomal diseases is now practiced on a broad scale; it made it possible not only to assess the detriment of hereditary diseases to the population as a whole, but to control disturbances in function of the genetic program in individuals.

However, at the present time, in addition to problems of genetic burden, we are concerned with another, even more important aspect of the genetic program, the proper function of normal alleles, which should assure health.

The problem of regulation of function of normal alleles in the course of development of individuals and function of organs and tissues, including cells referable to the system of higher nervous activity, is a complex one. Hormonal influences, stress, adaptation to extreme conditions and other influences are obtaining their definitive interpretation, based on changes in biochemistry of gene function in the relevant parts of the human body.

It has to be stated that developmental biology is still not elaborated, with respect to determination of the laws of expression of the genetic program in processes of individual development. Its problems will be solved on the basis of consideration of the unity of integrity and discreteness in expression of the genetic program. Just how little we know about the essence of genetic phenomena in the human soma can be illustrated by the two following examples, obtained very recently. It has been long known that mitotic crossing-over is widely represented in the prophases of mitosis of somatic cells, as they divide in developing tissues. In the last few years, this phenomenon was investigated in plant cells. In 1955, J. Taylor demonstrated the existence of exchange between sister chromatids in mammalian cells. The level of mitotic crossing-over rises sharply under the influence of mutagens. We know of mass scale exchange between sister chromatids in human leukocytes under the influence of a mutagen (4-nitroquinoline-1-oxide). Appearance of unequal exchanges with subsequent crossing-over between nonsister strands should lead to formation of chromosomes with deletions and duplications, on the basis of which clones of genetically receding cells could develop in the human body.

Another example is the discovery of new functions in the complex of human tissular incompatibility, HLA. A link was discovered between HLA antigens and immunity to viruses and a number of diseases, which creates the conditions for hereditary predisposition of humans for polygenically determined diseases. Antigen B27 is found in 90-95% of the patients with ankylosing spondylitis (Bekhterev's disease). Studies are in progress in a laboratory of the Institute of General Genetics, USSR Academy of Sciences (I. K. Yegorov) on the link between HLA and predisposition for tuberculosis. Intervention in

phenomena of tissular incompatibility is largely related to development of the problem of regulation of gene action. The social significance of solving the problem of tissular incompatibility is exceptionally great, since the most important problems of safeguarding health could be resolved by means of tissue and organ transplantation. New methods could be made available to clinical medicine if the bases of genetics of tissue compatibility are identified.

Ultimately, appearance of malignant growth is also related to impaired regulation of gene action. Such a disturbance occurs in an individual somatic cell under the influence of chemical and physical mutagens, or oncogenic viruses. A cell with a specifically altered genetic program is no longer under the influence of regulatory mechanisms of the body as a whole and generates malignant tissue.

Environmental mutagens: Pollution of man's environment is an enormous problem, which developed for mankind in view of development of the scientific and technological revolution. Along with ecological consequences, we should expect genetic effect . The latter is attributable to the fact that mutagens appear in the environment in the form of chemical, physical and biological factors capable of inducing mutations. It is unquestionable that environmental mutagens induce mutations in human somatic and embryonic cells. Under normal environmental conditions, heredity of the population was characterized by its health as a whole. The volume of the genetic burden was an equalized factor and led to appearance of about 4% genetically deficient children, without disrupting the genetic structure of the population as a whole.

When the environment began to be polluted by mutagens, the situation changed and the process of additional pressure of mutations began, which increased the incidence of pathology among neonates. An increase in number of neonates with genetic defects must result from the process of deformation of heredity of mankind. Genetics was faced with a social task: To furnish a qualitative and quantitative assessment of the effects of environmental mutagens, to try to predict the consequences of processes that may occur in the next years and decades and, finally, to develop methods of protecting DNA from the deleterious effects of environmental mutagens.

This matter is of exceptionally great importance. At the present time, in industrial countries such as the United States, France, FRG, Japan and others, about 10% of the neonates have genetically determined defects. What should we expect in the next few years, in the presence of increasing pollution of the environment by mutagens? An increase in level of the genetic burden in excess of 10% (which could happen by the end of the 20th century) could cause enormous demographic and psychosocial changes.

To what extent is alarm justified concerning the future of human heredity in the light of data indicating increased environmental pollution by mutagens? In the first place, sensitive test systems are being developed that permit

direct genetic monitoring of growth of mutagenic properties of the environment. Ultrasensitive bacterial systems (gene mutations) and human leukocytes in culture (structural and other mutations of chromosomes) are considered the important ones. Thus far, methods have not been developed to extrapolate these data to human embryonic cells. In the second place, it is necessary to analyze the rate of mutations in human embryonic cells proper, which would permit evaluation of the integral effect of environmental mutagens on population genetics. This turned out to be very difficult. There is a major center for birth defect monitoring in the United States, in Atlanta (Birth Defects Monitoring Program). This center is concerned with four projects: investigation of neonates in the city of Atlanta (Georgia), of the entire population of the United States and, finally, eight countries of Europe; Sweden, FRG, Norway and others. About 3% of the total number of genetic defects was submitted to investigation (Congenital Malformations, 1977). The limited sample and vagueness of range of anomalies did not make it possible to obtain reliable data, which would answer the question of whether the overall genetic burden in human populations was holding at the same level or rising (from 1970 to 1976, which this monitoring was pursued). The monitoring conducted at the center in Atlanta establishes differences in number of pathologies in different territories. Demonstration of such factors revealed the existence of dynamics to the size of the genetic burden on the population of the United States. Distinct growth in the last 5 years was demonstrated for some defects, such as congenital dislocation of the hip. The same was corroborated by data obtained in Canada.

At the present time, J. Neel is working on a large project to substantiate monitoring of appearance of mutations in human populations by methods of biochemical genetics (Neel, 1974). These are quite large and expensive studies. Another approach was substantiated in the works of the Institute of General Genetics, USSR Academy of Sciences (Dubinin, Altukhov, 1976; Dubinin et al., 1975). Using the records of one of the maternity homes in Moscow, we characterized neonates and their mothers according to blood types ABO, MN, P, Lewis and Rhesus. We established differences from the means of five quantitative characters (weight, height, circumference of the head, chest and abdomen) for each of 462 infants. The mean group (M) consisted of 118 children, there were 81 in the group with the worst combinations of quantitative features (M^-) and 88 in the group with the best combinations (M^+). With respect to biochemical markers, the infants in the average group (M) were genetically the most diversified. According to the results of demographic and genealogical analysis, the M^+ and M^- children had parents from different, geographically distant populations. While there was no genetic burden in the M children, this burden was large for M^- children and appreciable in the M^+ group (Dubinin et al., 1976).

These data are indicative of the adaptational significance of the demonstrated differentiation in the population of neonates, among whom the average group, with optimum heterozygocity, was the most viable. The distribution of neonates according to extent of defect burdens, with due consideration of their origin in that generation, is indicative primarily of manifestation of a segregation burden. In view of the fact that many mutations in man have

a negative influence, it may be assumed that, with the gradual saturation of the population with such mutations, there will be an increase in number of individuals in the M^- and M^+ groups. This applies particularly to the M^- group, which accumulates the genetic burden of the population the most. This shows that the distribution of polygenic tags in neonates, due to a decrease in number of individuals in the average class and with increase in number in M^- and M^+ groups, is indicative of diminished adaptation of the population as whole, by virtue of an increase in both the segregational and mutational burdens.

The nature of congenital defects in children is complex: a mutational and segregational burden is manifested in neonates; teratological deviations, which occur as a result of deleterious effects on fetal development, and depend on changes in the postnatal period in phenotypic value of genotypes in the new environment generated by the scientific and technological revolution. Monitoring of the entire range of disturbances in neonates in the postnatal period as well is of great importance. However, with the usual approach to recording defects, it is difficult to single out the mutation burden and track changes therein over a period of several years.

The above-described method of searching for mutants among neonates that deviate from normal in a number of characters indicates that, on the basis of methods of biochemical, population and demographic genetics, we are able to monitor appearance of mutations in the population on a relatively small sample and, using certain additional analytical procedures, we can relate these estimates to environmental parameters.

There is one category of genetic changes that permits evaluation of prior processes in human heredity. The appearance of malignant growth is induced by changes in the genetic program of individual somatic human cells. The cause of the changes is referable to exogenous factors that induce carcinogenesis, including chemical compounds, physical factors, viruses, etc.

It has been proven that carcinogenic factors are capable of inducing mutations in over 90% of the cases. There are no data referable to the human body on quantitative correlations between carcinogenesis and mutagenesis; however, the parallelism of these phenomena is unquestionable.

The death statistics in the United States (Silverberg, 1977) indicate that 18.4% of the people die due to cancer at the present time. Such an incidence of cancer did not exist 45 years ago. It was shown that 6 out of 7 forms of malignant growth began to appear in many people in the period from 1930 to 1975. There was a reduction in incidence of carcinoma of the stomach, and this is related to improved sanitary qualities of food. In 1930, the mean number of cases of these six forms of cancer was about one-third the number in 1975.

Monitoring of the incidence of cancer is demonstrating clearly a trend toward increased effectiveness of influence of mutagenic factors on the human body. The rise in genetic lesions to man with increase in environmental pollution

by mutagens is proved by the rise in incidence of cancer. The problem is to make a quantitative analysis of this phenomenon. The social implications of disturbances induced by environmental mutagens in human genetics may be exceptionally great. Genetics is called upon to assess this phenomenon and prevent continued introduction of mutagens into the environment, as well as to find methods of protecting human DNA from the deleterious effectsof mutagenic factors.

In phenomena related to the effects of enivronmental mutagens, man encounters the problem of his new situation in the environment, which was altered through his activities. Forecasting the increase in genetic injuries is the greatest task for genetics, and it has enormous social significance.

The Problem of Man and Genetics

The problem of man is of enormous scientific and practical significance. Apparently, as a social being, man is the product of history; as part of nature he expresses biological phenomena. After the appearance of the science of social inheritance and existence of two programs in man, genetic and social, the general teaching on the biosocial nature of man gained a new impetus for development. In spite of the old views of sophisticated heredity, that some human traits have a biological basis and others, social, it became obvious that development of man takes place on the basis of the dialectical unity of biological and social factors.

For this reason, man became a qualitatively special phenomenon, distinct from animal species. The depth of unity of biological and social factors in man can be clearly seen from the fact that, in him, expression of the genetic program depends on interaction with social factors. This is the most apparent on the example of development of speech, which appears only when a child learns it. Without this, speech does not appear, and this leads to a number of consequences with respect to structural and functional development of the brain.

An infant is born as a unique being, prepared by biological evolution to develop the traits of man. However, this properties develop through the dialectics of biological and social factors. Soon after birth, the infant interacts with factors in the social environment, as a result of which his genetic potential is realized. His spiritual life and morphophysiological development take place on the basis of this interaction. Heretofore, there was underestimation of the significance of the social factor in early development and at the critical stages of development. Let us cite the thoughts of L. N. Tolstoy, who wrote in the novel, "Anna Karenina," about the infant of the Levins: "To Agaf'ya Mikhaylovna, to the nanny, grandfather and even to the father, Mitya was a living being who required only maternal care; but to the mother, he had become long ago a moral being, with whom there had already been an entire history of spiritual relations."

The dialectics of social and biological factors points to the route of development of rational man, by means of feedback, in this process the social

factor created the the direction of biological evolution. This process, called the phenomenon of harmonizing evolution, provided for the response of biological evolution to the conditions in man's suprabiological social sphere. The social factor, determining the direction of selection for mutations and recombinations in evolution, which led to appearance of Homo sapiens, was imprinted, so-to-speak, in man's genetic program. As a result, at birth, before man has experienced the effects of the social factor, he is found to be biologically prepared for entering into the social form of movement of matter. This led to creation of the appearance of man, which has no analogue in the animal kingdom, to formation of the genetic program which, being inherent in man, is the prerequisite for his social life.

Eugenicists, who recognized the rigid biological consolidation of elements of man's social behavior, believed that formation of a new man can occur only if his genetic program is altered. Previously, it was thought that this goal could be reached by means of breeding superior races; in our times, it is believed that it can be reached by means of genetic engineering. In the light of the teaching on biological and social aspects in man, development of human properties is a dynamic process, in which social factors play the leading role. This serves as the natural scientific basis of the Marxist-Leninist teaching on shaping new man by altering social conditions. The human personality is based on individualized dialectical unity of social and biological factors in each specific person. This is the basis of the uniqueness of each individual and, at the same time, typification of the forms of his social behavior. This is how the conditions under which socialism developed led to creation of humane man, an active builder of a socialist society.

The dialectics of the social and biological factors in man opens new inroads in the study and solution of problems of pedagogics, psychology, jurisprudence, for all aspects of the teaching about man.

Some Problems of Genetic Engineering.

Among the achievements of modern genetics capable of influencing the life of society, those referable to genetic engineering have drawn particular attention in recent years. The substance of these achievements consists of the fact that, by obtaining recombinant DNA molecules and inserting them in a selective cell, logically conceived models are created in the form of living systems. Certain bacterial genes have thus been transferred to the cells of other bacteria. For example, a strain of Escherichia coli was created, which acquired the capacity to fix nitrogen due to a gene transferred from Klebsiella pneumonia. The genes of higher forms, such as the ribosomal genes of the Xenopus frog, yeast, sea urchin, silkworm, drosophila, chickens and chloroplasts, were cloned in bacteria. By changing the genetics of fungi and bacteria, it is possible to develop new producers of drugs and other valuable substances with supersynthetic properties. There has been a report on the insertion of of the rat insulin gene in the DNA of E. coli bacteria.

We are impressed by the work of a number of scientific teams pertaining to insertion of the nitrogen-fixing genes in the genome of higher plants. In March 1977, there was a conference in the United States (Johnston, 1977), entitled "Genetic Engineering of Nitrogen Fixing." The transfer of parts of the human genome to bacteria and other microorganisms is extremely promising. In this case, needed human macromolecules could be synthesized on an industrial scale. This applies to insulin, hormones, antibodies, vitamins, etc. If it will be possible to transfer normal alleles to people with genetic defects, gene therapy will also be feasible, i.e., curing patients by restoring the functions of normal alleles.

In addition to gene engineering, for man, we cannot rule out engineering on the cellular level. It may be possible to perform cloning by means of transplantation of nuclei from the somatic cells of an individual to anuclear ova. Methodologically, it is simpler to produce allophenic people by combining cells from several embryos. In such an individual, the body would contain cells from four or more parents with different genotypes, which could create heterotic conditions for development. Ova or embryos, altered by means of genetic engineering, could be impalnted in the uterus.

A new route for analysis of genetics of higher forms is one of the important "spin-offs" of gene engineering. In man, each cell has hundreds of thousands of genes. If human genes are transplanted, one by one, by recombination with the DNA of E. coli and cloned, it would be possible to identify the function of each of them. As a result, all of the genes in the 23 pairs of human chromosomes would be precisely localized, counted and studied.

The advances in the field of recombinant molecules promise to revolutionize agriculture, livestock raising, the microbiological industry, medicine and scientific research in the field of genetics and molecular biology.

However, it must be borne in mind that the methods of genetic engineering harbor a danger to society. The risk of such research lies in the possibility of appearance of lethal recombinant molecules. If organisms with such molecules escape the confines of laboratories, they may present a serious threat to human life. Very broad research is being pursued on genetic engineering. In the United States, more than 80 university laboratories and laboratories in 9 private companies are producing recombinant DNA molecules. The stormy reaction of public opinion and expressions of a sense of social responsibility by a number of scientists constitute a distinctive feature accompanying the development of methods of genetic engineering. While this process was far removed from society at the birth of nuclear energy, in laboratories of experimental physics, the appearance of data pertaining to genetic engineering immediately linked genetics with public opinion and politics.

There has been recognition of the necessity for great caution in conducting experiments dealing with production of recombinant molecules. This should be implemented in two directions. In the first place, special laboratories must be created, providing protection to scientists within the laboratories, and a

sterilization system that would now allow infectious material to leave the laboratory without being decontaminated. In the second place, it has been recommended that research be done with special forms of bacteria that are not viable outside the laboratory environment. For example, one could create a strain of bacteria that perish upon contact with the salts of the human body. It is difficult to state to what extent these precautions will reach the goal.

Genetics and scientific thought: Genetics plays a very large role in modern scientific Marxist-Leninist views of nature and society. This is indicated by the above sections dealing with the link between genetics and social problems. Proof of the material nature of all of the main phenomena of life is of enormous significance. In this respect, it is of exceptional importance to establish that the informational source [principle] of living systems is contained in material structures of nucleic acids. It has been found that interaction between proteins, nucleic acids and energy received by the cell from without is of decisive significance to phenomena of life. All this has contributed to the contents of the dialectical materialistic teaching about life as a special form of biological movement of matter.

Awareness of all the importance of the ideas and data of modern genetics to a scientific world outlook depends basically on proper comprehension of the historical origin of the principles of new genetics.

V. I. Lenin (in "Poln. sobr. soch. [Complete Collection of Works], Vol 49, p 329), in substantiating the significance of the historical method, wrote that it is imperative to know, for each phenomenon, when it occurred and what stages it underwent. One cannot learn the results without learning the routes of development of a given phenomenon.

The dominant theme in the ideas of many leaders in genetics of the 1920's was rejection of the principle of interaction between internal and external factors in the problem of mutations. It was believed that genes do not change, or that changes (mutations) therein occur only under the influence of endogenous causes. The appearance of mutations was considered a process that was presumably totally independent of environmental conditions.

In 1925, G. A. Nadson and G. S. Filippov showed that x-rays induce mutations in yeast cells. Their work did not gain recognition, because it contradicted the autogenetic views of those times. In 1926, 1 year after this discovery, A. S. Serebrovskiy, who did not abandon the theses of autogenesis, wrote: "We see that mutations are by no means the result of laboratory or generally any exogenous conditions. On the contrary, extensive experiments with the drosophila have shown that not only is it impossible to induce any specific mutation by altering external conditions, but it is generally impossible to enhance or attenuate the mutating activity of an organism."

The creation of modern theory of mutations is a vivid example of dialectical elimination of contradictions. This theory established the dialectics of the

endogenous and exogenous. Instead of the idealistic interpretation of autogenesis, which separated heredity from the environment, it was shown that genes are only relatively stable. Instead of the Lamarckian views of adequate inheritance of personal acquired properties of organs, there was demonstration of the role of environmental factors in inducing mutations.

Modern methods of inducing mutations, the link between mutation theory and agriculture, the microbiological industry and medicine, the enormous significance of the problem of environmental mutagens and development of the philosophical bases of genetics--all these appeared and developed, overcoming the mistakes of autogenesis and Lamarckism. This is merely one episode from the history of overcoming the errors inherent in genetics in the 1920's-1930's.

In conclusion, it should be stated that modern genetics is starting on the next enormous turn of its spiraling development. In our times, genetics is becoming an enormous material force, it has advanced to the leading ranks of natural science. We have an exceptionally great responsibility to society. We must make a profound evaluation of the opportunities that are offered by the advantages of socialism to science and practice in the use of the advances of genetics, and place this science entirely at the service of our people.

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CSO: 1870

UDC: 614.71/.72:66

THE ROLE OF TECHNOLOGICAL AND LAY-OUT FACTORS, AS WELL AS CLIMATE, IN FORMATION OF THE AIR BASIN IN THE REGION OF CHEMICAL PLANTS

Moscow GIGIYENA TRUDA in Russian No 6, 1978 pp 6-11

[Article by A. P. Mikhayluts (Kemerovo), Medical Institute, submitted 20 Oct 77]

[Text] The hygienic aspects of formation of the air basin in the region of chemical plants and substantiation of sanitary specifications were discussed in the works of A. S. Arkhipov, Ye. N. Marchenko (1962), N. F. Izmerova (1974), V. A. Polyanskiy and A. N. Musserskaya, V. S. Nikitin and others. At the present time, in view of the development of large chemical centers, removal of equipment to outdoor areas and introduction of the modular-unit system of lay-out, these questions are growing more important, as indicated by A. S. Arkhipov et al., N. F. Izmerov (1973). It must be noted that the role of some of the characteristics of technological and lay-out treatments, climate in formation of the environment in the regions of chemical enterprises has not been adequately evaluated from the standpoint of hygiene.

For this reason, studies were conducted at three major chemical enterprises involved in the production of caprolactam, mineral fertilizers, methanol, ammonia, dimethylformamide, mineral acids, sulfenamide C, ion exchange resins, ethylene and others, the objective of which included substantiation of the use of a number of parameters of technology, lay-out and climate for implementation of preventive and routine sanitary inspection of atmospheric air in outdoor production areas of chemical plants.

In addition to gathering technical and lay-out characteristics, determination was made of concentrations of toxic substances in atmospheric air, snow, natural illumination and aeration conditions. The environmental parameters were measured at both permanent points of of the extra- and intra-section [block] areas of production, as well as with a torch at different distances from the sources of exhausts and in the plant as a whole. Toxic substances were also assayed in the exhaust from ventilation systems and in the air of outdoor areas with equipment. Air samples and measurements were taken in 8-12 points at one time. The overall volume of the studies constituted 8120 air samples and 470 samples of snow for detection of chemical compounds, 2450 measurements of illumination and 3320 measures of air velocity. The

data obtained from these studies were submitted to computer processing, using two-factor variance, multifactor correlation and regression analysis.

As a result of the fact that there is incomplete trapping at treatment plants, and there are no systems and methods for purifying waste of low concentrations, as well as the increased capacity for migration from equipment, the share of overall discharge of compounds that are difficult to recover per ton of raw material or final production is 3.9-4.7 times greater at the plants studied than that of readily recovered substances.

The sanitary situation is made particularly deleterious in those cases where substances that are difficult to recover, with the same type of action, are used in various production processes at large enterprises. At one of the plants, we observed formation of massive emissions of ammonia, nitrogen oxides, sulfur dioxide, aerosol of sulfuric acid, which constitute as a whole hundreds of kilograms per hour. As a result, the overall concentrations of irritant inorganic compounds reached 0.37-0.81 of the MPC [maximum permissible concentration] in the work zone air over a large part of the enterprise territory.

From the standpoint of hygiene, a basic change in technological processes at the stages involving the use of poorly recoverable substances is effective. Thus, direct catalytic synthesis of hydroxylamine sulfate, which is being adopted in caprolactam production, eliminates several technological stages, reducing emission of nitrogen oxides by 67 kg/h, sulfur dioxide by 95 kg/h and ammonia by 53 kg/h.

Among the characteristics of technological process, of interest to preventive and routine inspection are data on overall emissions of toxic substances and emissions from unorganized sources (open areas with equipment, ventilation systems, overhaul work, etc.) per ton raw material or end product. The use of these indices made it possible to determine that the overall emission of toxic substances per ton product is higher in the industries of mineral fertilizers, caprolactam and dimethylformamide than methanol, sulfenamide C, ammonia and ethylene. In addition, it was found that with the use of equipment of greater unit power for the production of caprolactam there is a 14.5-18.2% reduction in emission of ammonia and sulfur dioxide per ton product.

Our studies revealed that at enterprises covering 110-240 ha territory, in the presence of regular, recurrent inversions, processes of primary dissipation of emissions of toxic substances occurs primarily within the plant territory. This is attributed to the fact that, at the plants, 44 to 85% of the overall emissions of toxic substances are from low, linear sources (emergency technological, ventilation emissions, open areas with equipment, overhaul work, tank filling areas) at a height of up to 40 m. It should be noted that the negligible altitude of emissions (20-60 m) and dissipation thereof within the territorial boundaries of the plants are typical of chemical plants (Ye. N. Marchenko, 1969; A. S. Arkhipov et al.; V. M.

El'terman; V. T. Samsonov et al.). As a result, one can determine the effects of the plants on the air basin of outdoor production areas on the basis of the overall volume of air required to dilute to permissible levels (0.3 MPC of the air of work places) of the emissions in the atmosphere of toxic substances that are dissipated within the boundaries of the plant. The proposed index is the sum of ratios of emissions of different substances, in kg/min, to the permissible levels thereof at air intake points. For example, 1.7 million m^3/min air is required to dilute emissions of inorganic irritant compounds within the confines of the enterprise in the case of caprolactam production 5.1 million m^3/min in sulfuric acid production, 0.16 million m^3/min for ammonia and 0.08 million m^3/min for sulfenamide C.

It is interesting that, during periods of inversions and calm, a reliable, nonlinear correlation of the parabolic type (0.69 correlation) is demonstrable between the volumes of air required to dilute toxic emissions and the extent to which their concentrations exceed the permissible level in the dissipation zones. During periods of calm and inversion, the extent of air exchange in some parts of plant territories does not provide for the required dilution of toxic substances, which has an adverse effect on purity of air at the air intake points. Thus, pollution of air in intake ventilation systems, which we demonstrated to be 1.4-2.2 times greater than the permissible level, is attributable, on the one hand, to massive emissions that require considerable volumes of air for dilution and, on the other hand, access of toxic substances from numerous sources, not uncommonly at a height of 2-3 m (outdoor areas with equipment).

There is an unstable rate of emissions from sources of pollution of atmospheric air of enterprise territories. According to our data, the overall yield of inorganic irritant compounds, emitted with organized technological waste, changes on the average by 1.6-2.6 times, emissions with ventilation exhaust change by 3.1-7.7 times and from outdoor areas with equipment, by 3.9-8.1 times. On the whole, the fluctuations of emissions attributable to different extents from different sources constituted a 2.3-4.8-fold range. Such rates of emission lead to considerably dynamic concentrations of toxic substances in atmospheric air of industrial areas. Thus, under the same weather conditions, the coefficient of variation of concentrations in the atmospheric air of plant premises is up to 62-85%, while the correlation between the range of fluctuations of overall emissions and coefficient of variation of concentrations under conditions that are not favorable for dissipation constituted 0.57-0.73 in different plants ($P<0.05$).

The direction of the long axis of buildings, mutual location of plants and outdoor areas with equipment are among the characteristics of lay-out treatments that are of substantial significance to formation of the air basin on the territory of chemical enterprises.

Orientation of the long axes of buildings in relation to the wind rose determines the probability of involvement of spaces differing in area in

the zones of air shadow and currents of air. According to data in the literature, the concentration of toxic substances is 6-8 times higher in areas of air shadow than elsewhere (I. N. Leykin; V. M. El'terman). We established that the ammonia content constituted 0.6-0.9 g/m^2, that of sulfates was 1.7-2.1 g/m^2 and cyclohexanone 0.18-0.32 g/m^2 in the snow of areas that were often in the zone of air shadow, whereas in areas beyond this zone the levels were decreased to 1:1.6-1:3.9. During periods of impaired inversions in the zones of air shadow, the concentrations of toxic substances drop more slowly for 1.5 h than in the areas with air currents. Under the existing standards for percentage of construction of territories, spaces between plants and buildings, as well as the existing lay-out principles, an adverse sanitary situation is created, due to reduction of zones with air currents, in outdoor areas of chemical plants when frontal zones of air shadow occur near buildings and outdoor installations with equipment. In such cases, 69-88% of the intrasection spaces are in the zone of the air shadow, versus 31% with appearance of end zones of air shadow.

With the mutual arrangement of factories within a plant under conditions of adopting the system of modular unit lay-out (M. Ye. Ostrovskiy et al.), the question arises as to which index to use to compare the deleterious effects of factories on the surrounding territories. For this reason, we assayed the concentrations of toxic substances in the air of the territories of different factories when they were in the range of influence of emissions from other factories. We compared the levels of pollution of atmospheric air to the volumes of air required to dilute emissions from factories on the lee side. In assessing the effects of emissions on the level of air pollution in adjacent factories (80-200 m distances), we took into consideration the amount of air required to dilute the toxic substances of the factory exerting an influence, emitted at an altitude of up to 40 m. When the factory at fault was 500 m or more away, we also took into consideration the dilution levels required for all emissions.

Table 1 shows that the overall concentrations of irritants in the air over the territory of the factories increase by 1.2-4.4 times when emissions migrate from factories on the windward side. Using variance analysis, it was established that the share of statistically reliable influence of emissions from some factories on the level of atmospheric air pollution at others constitutes 27-69% (see Table 1). In turn, it depends on the extent to which emissions are diluted to the permissible level, distance between factories and altitude of emissions. Consequently, when settling questions pertaining to the relative location of factories on the territory of chemical enterprises covering large areas, it is expedient to take into consideration the amount of air required to dilute the overall emissions.

When equipment is situated in the open air, a linear (coefficient of correlation 0.68-0.89) and nonlinear (correlation 0.70-0.93) functions exist, within a radius of up to 20-25 m, between the levels of chemical compounds in the air of the surrounding spaces and their concentrations on outdoor installations. Since outdoor yards with equipment are very often close to

buildings, the air intakes of ventilation systems may be in the zone of their influence. At the same time, there are different hygienic specifications for purity of air in outdoor areas with equipment and at the points of air intake equipment, so that toxic agents present at the MPC level or lower in the air of outdoor installations does not necessary guarantee that the sanitary standards for surrounding space are met, and we observed this in 12% of the cases.

Table 1. Reciprocal influence of emissions from different factories on level of atmospheric air pollution

Factory	Overall emissions, kg/h	Air for dilution of substances, m^3/h million	Total concentration, %MPC: without influence of other factories	Total concentration, %MPC: with influence of other factories	Factory exerting influence	Share of factor of influencing factory, %
Caprolactam	328	198	44	63	Mineral fertiliz.	37
				76	Sulfuric acid	54
Sulfuric acid	154	311	56	71	Caprolactam	60
				65	Mineral fertiliz.	42
Mineral fertilizers	257	164	37	51	Caprolactam	27
				48	Sulfuric acid	46
Sulfenamide C	24	4,3	7	31	Sulfuric acid	69
				23	Mineral fertiliz.	51

Table 2. Concentration of toxic substances in atmospheric air of territory of factories as related to weather conditions (M±m)

Factory	Substance	Concentration, mg/m^3: fog	inversions	period without inversions	wind veloc., m/s: up to 2	7-8
Caprolactam	Ammonia	4,28±0,38	4,16±0,31	1,63±0,20	3,70±0,33	1,42±0,19
"	Nitrogen oxides	2,45±±0,22	2,33±0,18	1,09±0,16	1,76±0,14	0,98±0,13
"	Cyclohexanone	3,94±±0,31	6,12±0,49	1,42±0,21	4,37±0,36	1,84±0,27
Sulfur.acid	Sulfur dioxide	1,96±0,24	3,38±0,26	1,45±0,19	2,77±0,25	1,35±0,17
Miner.fertil.	Nitrogen oxides	3,21±0,28	2,90±0,26	1,76±0,22	2,45±0,20	1,33±0,16
Sulfenamide C	Hydrogen sulfide	1,88±0,20	1,94±0,12	0,83±0,11	1,54±0,12	0,69±0,10
"	Ammonia	1,38±0,12	1,68±0,08	0,51±0,09	1,93±0,18	0,36±0,04

The weather conditions affect the level of pollution of atmospheric air of production yards of chemical plants. Table 2 shows that there was a 1,7-4.3-fold increase in levels of toxic substances on the production territory in the presence of inversions, calm wind conditions and fog.

From the hygienic point of view, it is imperative to take into consideration the probability of recurrence of meteorological conditions in a given locality that would be associated with increased pollution of atmospheric air (see Table 2).

Conclusions

1. Formation of the air basin in the territory of chemical plants is largely determined by the composition, size of factories, toxic substances used in technological processes, area occupied by the plants, direction of the long axis of buildings in relation to the wind rose, reciprocal placement of factories, location of outdoor areas with equipment, recurrence and duration of weather conditions that are not favorable for dissipation of emissions.

2. It is expedient to use the technological and lay-out indices, as well as climatic characteristics, for preventive and routine sanitary inspection of the air basin of chemical plant yards. Such indices include the following: overall emission of toxic substances per ton final product; share of emissions from different sources; emission of toxic substances from unorganized sources per ton final product; amount of air required for dilution of overall emission of toxic substances dissipated within the confines of plant premises to permissible levels; incidence (as percentage of the year) of frontal zones of air shadow around buildings and equipment yards; percentage of land that would be included, with a high probability, in the range of influence of powerful sources of air pollution; probability of recurrence of weather conditions that are unfavorable to dissipation of emissions.

3. A basic change in technological processes at the stages involving the use of compounds that are difficult to recover, as well as use of equipment with greater unit capacity, is effective in lowering pollution of atmospheric air.

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CSO: 1870

UDC: 613.632:613.155.3

ON THE QUESTION OF RAPIDLY SETTING HYGIENIC STANDARDS FOR INDUSTRIAL SUBSTANCES WITH IRRITANT ACTION

Moscow GIGIYENA TRUDA in Russian No 6, 1978 pp 50-52

[Article by N. G. Ivanov (Moscow), Institute of Industrial Hygiene and Occupational Diseases, USSR Academy of Medical Sciences, submitted 29 Jun 76]

[Text] It is growing increasingly obvious that, in view of the increase in number of substances used in industry and agriculture, there is a need to shorten toxicological experiments dealing with substantiation of MPC [maximum permissible concentrations] of chemical compounds in the air of work places.

For this purpose, several estimation and express methods have been proposed for setting the MPC on the basis of physicochemical constants and individual parameters of toxicity. One of the most promising ones is a method of calculating the MPC on the basis of the threshold of irritant action (Lim_{ir}) of a substance for man. Further development of research in this direction led to the conclusion that such a universal approach is not always justified, since the irritant properties are not the prime factor of development of acute and chronic poisoning. A study of 62 substances with irritant action revealed that there are poisons among them, the inhalation of which induces earlier development of irritation than changes in integral indices or functions of different organs and systems ($Lim_{ir}<Lim_{ac}$). It was suggested that such substances be called irritant poisons. The wider the range of irritant action of the toxic agent ($Z_{ir} = Lim_{ac}/Lim_{ir}$), the more inherent the irritant action is in the agent (I. V. Sanotskiy et al.). It has been established that Lim_{ir} is a limiting factor in setting hygienic standards of only the industrial substances with $Z_{ir}>1$. This is related to the fact that in the case of poisoning by inhalation of irritant toxic agents the changes in the respiratory system determine the symptomatology of acute and chronic poisoning. This is indicated both by the severity of disturbances of the selectively stricken respiratory system and the rate of development and incidence of changes in indices reflecting its condition (N. G. Ivanov et al.).

Analysis of the parameters of toxicity of irritant agents (sulfur dioxide, ammonia, nitrogen dioxide, bromine, hydrogen bromide, 2-chlorethane sulfochloride, bromacetopropylacetate, hydroperoxide, tertiary butyl, etc.)

established that there are specific correlations between the values of CL_{50}, Lim_{ac}, $Lim_{ir\ kr}$,* $Lim_{ir\ man}$ and MPC, on the basis of which two equations of multiple regression were proposed for calculation of MPC of these agents in the air of work zones:

$$\log MPC = 0.69 \log Lim_{ir\ kr} + 0.18 \log Lim_{ir\ man} - 0.7\ Z_{ir} - 0.51\ (mg/m^3)$$
$$(n = 27,\ r = 0.96,\ S_{xy} = \pm 0.21), \quad (1)$$

$$\log MPC = 0.11\ CL_{50} + 0.65 \log Lim_{ir\ kr} - 0.72\ Z_{ir} - 0.65\ (mg/m^3)$$
$$(n = 14,\ r = 0.91,\ S_{xy} = \pm 0.27). \quad (2)$$

On the basis of the common patterns demonstrated, a method is offered for rapid setting of hygienic standards for irritants with the use of experimentally determined values of Lim_{ac}, $Lim_{ir\ kr}$, $Lim_{ir\ man}$ and (if possible) CL_{50}, with subsequent calculation of tentative safe levels of the substances in the air of work zones using the above equations. The time required (not counting the time for developing the method of assaying the substance in air) for the determination by the proposed method constitutes 1.5-2 months. As a result of studies, the most adequate and informative indices of poisoning were selected, and they can be used in the rapid standard-setting method.

It is recommended that the Lim_{ir} for rats be determined on the basis of a set of indices, including respiration rate, "acuity of olfaction" by the method of N. G. Ivanov et al., cellular reaction of the lungs and upper respiratory tract (method of LaBell and Brieger as modified by L. P. Korotich) and vital staining of lung tissue (method of A. Ya. Azhipa).

To set the Lim_{ac} for animals, body temperature, motor activity, threshold-summation index, muscular strength, orienting reaction and oxygen uptake (by the method of S. V. Miropol'skiy) are recorded.

If there are indications that the substance in question affects a particular organ (or system), adequate tests must be used to evaluate their condition and determine the $Lim_{ac.spec.}$ according to the effect of the toxic agent on this organ (or system). One can use the proposed rapid method for setting hygienic standards only if $Lim_{ir\ kr} < Lim_{ac.spec.}$

Determination of Lim_{ir} for man is made with exposure for 1 min. The subjective sensation of irritation is the index.

Tests are made on albino rats and rabbits of either sex. In order to conduct the study using the proposed program, 200-300 rats and 32-48 rabbits are needed. The maximum statistical group consists of 8 specimens.

For determination of $Lim_{ir\ kr}$ and Lim_{ac} exposure time is 4 h. The animals are examined immediately after exposure.

*Expansions of subscripts: kr--probably refers to rats, rabbits or both; ac--active or acute.

The minimum effective concentrations of agents, which induced statistically significant (with $P<0.05$) changes in one or more integral (specific) indices in experimental animals, as compared to controls, are taken as the threshold concentrations, Lim_{ac} or Lim_{ir}.

Determination of CL_{50} of a substance is made on white mice with 2-h exposure, in accordance with the "Methodological instructions for running tests to substantiate MPC of toxic agents in work zone air."

It is preferable to calculate MPC in the air of work zones using equation (1). Calculations can be made using equation (2), if $Lim_{ir\ man}$ has not been established.

As can be seen by the magnitude of standard error of calculation of MPC using the above equations, the values of MPC for 67% of the agents will not differ from the stipulated levels by more than 1.6 and 1.86 times, and for 95% by more than 3.2 and 3.7 times, respectively. The selection of agents for tests using the proposed method is a very important factor.

At the present time, we can single out different groups of toxic agents with pronounced irritant properties. They include substances with acid and alkaline properties, organohaloid compounds, derivatives of organic acids and a few others. If a substance is referable to one of these groups of compounds, this serves as grounds for studying it by the proposed method.

The next stage of selection is to study the potency of irritant effects of substances on the skin, since there is a correlation between severity of effect of a toxic agent on the skin (or mucous membranes) and respiratory system (A. A. Golubev). The potency of irritant action is determined by the methods of Smyth and Carpenter, as well as Draize et al. The irritating effect is evaluated after 24-h application of the substance to the rabbit skin. Each concentration of the toxic agent is tested on eight animals. As shown by the results of our studies, substances with $Z_{ir}>1$ are referable to grade 3 or higher, according to potency of action on rabbit skin on the scale of Smyth and Carpenter.

The rather high precision of determining MPC of substances with the proposed method warrants recommending it not only for determination of tentative safe levels of industrial substances, but MPC of irritant toxic agents in work zone air. The time required for experimental substantiation of MPC using the proposed method, as well as cost thereof, are reduced to about one-third, as compared by the program stipulated in the "Methodological instructions for running tests for substantiation of MPC of toxic agents in work zone air."

Conclusions

1. It was established that there are certain correlations between the parameters of toxicity of industrial irritant toxic agents, which made it possible to formulate equations of multiple regression to calculate the MPC of such agents in work zone air.

2. A method was developed for rapid setting of hygienic standards for specific irritants, based on determination of CL_{50}, Lim_{ac}, $Lim_{ir\,kr}$ and $Lim_{ir\,man}$. The time required to substantiate MPC of toxic substances in work zone air is reduced to 1.5-2 months with the use of the proposed method.

3. The results of our experimental studies and calculations made with the proposed equations revealed that the proposed rapid method of setting hygienic standards for industrial toxic agents with irritant action is of satisfactory precision.

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CSO: 1870

UDC: 612-087:621.398

A VARIANT OF PORTABLE SINGLE-CHANNEL BIORADIOTELEMETRY SYSTEM

Moscow GIGIYENA TRUDA in Russian No 6, 1978 pp 56-58

[Article by A. A. Shaptala, V. S. Sautkin and V. V. Zabrodin (Donetsk), Medical Institute, submitted 2 Mar 76]

[Text] The design of means of telemetric recording of physiological data made it possible to develop hundreds of specific biotelemetry systems (V. V. Parin); however, practical application thereof is rather limited for a number of reasons, with the exception of space medicine.

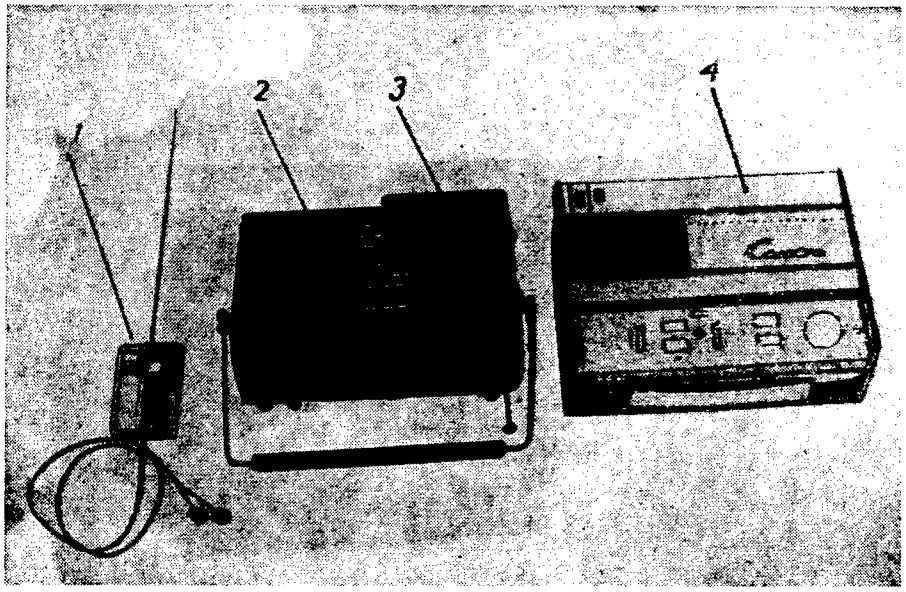
One of the chief reasons for the limited use of this method is the organizational and material difficulty of obtaining installations of the commercial systems (Sport, Opyt, Tsentr, Vega, TEK-1). In a number of cases, because of the relatively large weight and dimensions of the patient unit (Tsentr, TEK-1) their use is not desirable. The use of systems in industrial facilities, in the presence of industrial interference, is not very effective by virtue of the low output of the biological data transmitter and, not uncommonly, poor noiseproofing as well as sensitivity of the receiver (Sport, Opyt, Tsentr), and in some cases it is impossible. The mobility of decoding and recording units is limited in the Tsentr, Opyt and TEK-1 systems.

Consequently, there is still the acute question of wide use of available, simple and practical systems in industrial physiological practice for bioradiotelemetric studies of biological objects.

Research pursued on our chair in this direction resulted in development of a relatively simple, rather reliable, single-channel system for FM-FM dynamic radiotelemetry of any electrophysiological and some nonelectrophysiological indices limited to the frequency band of 0.2-300 Hz and amplitude of 0.01-10 mV (see Figure).

The high operational parameters of the units of the instrument, developed by specialists (R. V. Unelin; V. V. Rozenblat; Yu. G. Solonin; O. I. Vylegshanin et al.) made it possible to base this system on the type REK instrument, in which we made several alterations to increase the depth of frequency modulation of the biological signal, lower the influence of the high-frequency generator

on the modulator and amplifier, increase the output power of the transmitter by 2.5-3 times at a carrier frequency of 65.8-73.0 MHz (there are provisions for fine adjustment [or tuning] of the carrier.



Portable single-channel bioradiotelemetry system

1) patient radio unit
2) Ural-avto radio receiver
3) decoder
4) recorder (Salyut electrocardiograph)

Main technical parameters of portable, single-channel radiotelemetry system

Specifications	Amplifier	Modulator	Transmitter	Decoder	Receiver
Sensitivity	10 V	—	—	10 mV	5 V
Frequency characteristics	0.2—300 Hz	1700 Hz deviation ±400 Hz	65.8—73.0 MHz	—	—
Amplification factor	1000	—	—	120	—
Input resistance	120 C	—	—	1 M	—
Output power	—	—	100 mW	—	—
Supply voltage	9 V	9 V	9 V	12 V	12 V
Dimensions	84 58 25 mm with modulator & transmitter			110×55×22 mm	250×160×75 mm
Weight	110 g with modulator and transmitter			120 g	3,2 g

The commercial model, Ural-avto is used as the radio receiver, the actual sensitivity of which is 5 μV; however, virtually any portable radio receiver with autonomous power supply (Okean, Spidola-208, Ural-avto-2, Riga-103 and others) that has an ultrashort wave band can be used.

The decoder with tuning dial and output to a headset and recorder is plugged in the socket on the back wall of the Ural-avto receiver. The recorder is the very popular portable, commercial Salyut electrocardiograph, that can also carry its own power supply. The main technical parameters of the system are listed in the Table.

One year of operation of the portable system confirmed that it can be used in the presence of intensive industrial interference; it was highly reliable and portable. The recording (for example, EKG) was made at distances of up to 150 m from the subject (cleaner in heat-treatment section, rolling mill operator), while the heart rate was heard at a distance of up to 200 m. In the open air, recordings were made at distances of up to 400 m and audio monitoring, at up to 1000 m.

Specialists of average qualification can assemble the described system, which opens up the possibility of wide and practical use by many groups concerned with the study of various aspects of industrial physiology, especially remote forms thereof.

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CSO: 1870

INSTRUMENTS AND EQUIPMENT

UDC: 612.5-057:626.02

A METHOD OF RECORDING HEAT PARAMETERS OF DIVERS DURING WORK

Moscow GIGIYENA TRUDA in Russian No 6, 1978 pp 55-56

[Article by A. V. Sterlikov (Moscow), Institute of Water Transport Hygiene, submitted 17 Apr 76]

[Text] The chief difficulty involved in recording various physiological parameters of a working diver is the need to use a compound cable, in a sturdy water-proof insulation to transmit data from sensors. The diving suit has to be altered substantially to insert such a cable in the ventilated diving suit, to install an additional junction box gasket. In addition, the extra cable makes it difficult for the diver to work, because of its considerable weight.

We have designed a device that permits successive transmission of data from 12 temperature sensors over only two wires, to avoid the above inconveniences in recording the parameters of a diver's thermal status. This eliminated the need for inserting an extra cable in the diving suit, since it was possible to use free wires in the telephone cable of the diver to transmit signals from sensors secured on him. This is not associated with any disruption of communication by telephone. The described commutating device was used to take information from the sensors of skin temperature, sublingual temperature, temperature under the clothing and ambient water temperature when pursuing studies of heat exchange when a diver is working under water.

Thermistors with nominal resistance of 2.4-20 kΩ served as the sensors.

The key diagram of the device is illustrated in the Figure. The signal is delivered from the sensors to the telephone cable through a switch in the diving suit. Successive connection of sensors to the transmission line is performed by means of a step-type selector. The step-type selector is operated in the following manner: A dry type 373 element is connected for a brief time on the surface to the transmission line by means of button $Кн_1$. This causes transistor T_1 to open, contacts of relay R_1 to close, and condenser C_1 is discharged through the winding of the step-type selector. The armature of the step-type selector is attracted, and the measurement channel

is switched. Condenser C_1 is charged by the voltage transformer which is mounted on transistor T_2. The battery (3 type 373 elements) that powers the voltage transformer is also in the diving suit. There is a type MVU-49 direct current bridge to measure sensory resistance, then the temperature is found on calibration graphs. The basic circuit of transistor T_1 does not shunt the sensors due to incorporation of a diode with high reverse resistance, which is over 1 mΩ. When temperature is measured, current is fed to this diode with reverse polarity and locks it. To increase the reliability of operation of the commutator, the contacts of all three of its cards [plates] are connected in parallel. In assembled form, the switch [commutator] is 130×95×40 mm in size. The battery is put in a separate case.

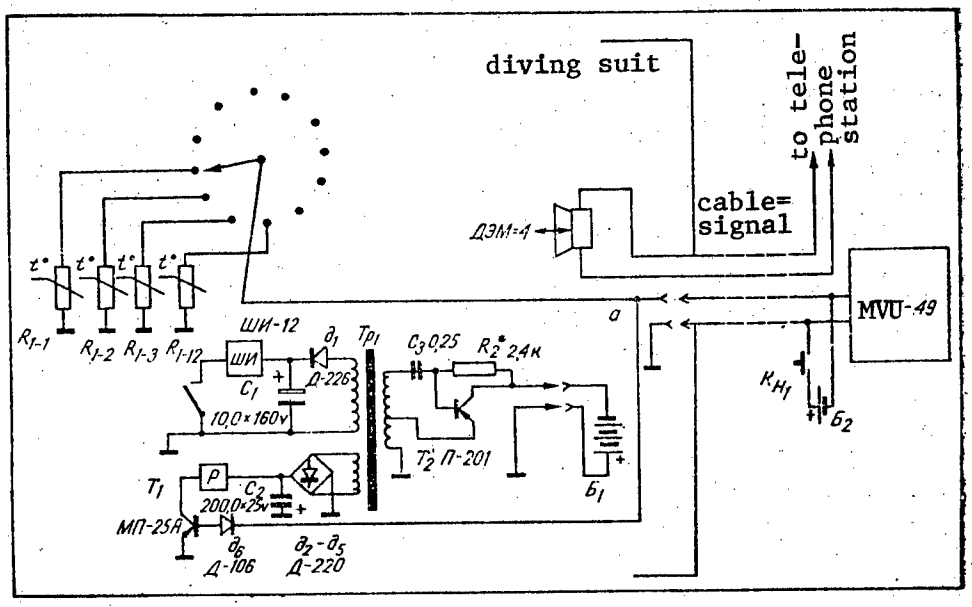

Diagram of commutator for multichannel thermometry over a two-wire line (of diver's telephone station)

When taking readings, the temperature sensors were attached to the skin by means of rubber bands. The sensor for sublingual temperature was secured in the helmet of the diving suit in such a manner that the diver would be able to put it in his mouth when so ordered from the surface. The ambient water temperature sensor was let out of the diving suit through the elastic flange of the diving shirt.

Before conducting tests using the described equipment, the diver's telephone station was prepared in the following manner: sockets were soldered to the free cable wires at both ends of the teflon cable (in the helmet on one end and near the diver's station on the surface at the other end) to make it easier to connect the switch with the telephone cable when the diver

puts his suit on before submerging, as well as to connect the direct current bridge to the cable on the other end.

Before starting the measurements, a reading was taken of cable resistance in order to then make a correction in the reading of sensor resistance. Temperature fluctuations of cable resistance will not have an appreciable effect on the results of the readings since, in the first place, this resistance is many times lower than the resistance of the sensors, and in our studies it constituted 10 Ω; in the second place, the temperature coefficient of resistance of cable conductors is many times lower than the temperature coefficient of resistance of thermistor sensors.

The described equipment was used in field studies, when divers submerged to a depth of 60 m in the Black Sea.

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ANALYSIS OF THE SPECTRAL CHARACTERISTICS OF A DOSE FIELD BY THE THERMOLUMINESCENT METHOD

Moscow MEDITSINSKAYA RADIOLOGIYA in Russian No 5, 1978 pp 59-62

[Article by L. I. Masarskiy, USSR Ministry of Public Health Central Scientific Research Roentgen-Radiological Institute]

[Text] The characteristics of the spectrum of "effective" energy of roentgen radiation vary in different mediums. This results in significant errors in determining the size of an absorbed dose in heterogenic mediums. The precision of dosimetric measurements can be increased by assessing the spectrum of the acting roentgen radiation not on the basis of "effective" energy but rather on the basis of several energy lines. This work examines a technique for approximate determination of three energy lines in the spectrum in experiments using thermoluminescent detectors.

To determine the real dose distribution on a heterogeneous object exposed to roentgen radiation with 200-250 kev boundary energy, we must determine the spectral characteristics of the dose field. The purely analytical methods for determining the radiation spectrum at the place of dose measurement employed in radiation medicine and radiobiology cannot be used owing to difficulties associated with accounting for the effect of heterogeneity on the distribution of absorbed energy.

A technique for assessing the quality of "effective" energy in roentgen radiation, determined from the readings of two thermoluminescent detectors having different sensitivities to linear energy loss (6), has recently enjoyed widespread acceptance. However, this sort of information on the spectrum of acting radiation is sometimes not enough to satisfy the requirements imposed on the precision of such dosimetry in relation to a number of dosimetric problems. In particular if we must determine, with ±5 percent error, the dose absorbed by bone marrow in cavities within a bone structure irradiated by a roentgen source with an energy of 40-80 kev, we must know the energy of the acting radiation with an error of not more than ±5 kev (8).

The goal of the present work was to test the dependability of assessing the "effective" energy of a real spectrum of roentgen radiation and develop a technique for approximate determination of the radiation spectrum from the readings of two thermoluminescent detectors having different sensitivities to linear energy loss.

Materials and Methods

LiF and CaF_2 thermoluminescent detectors manufactured from monocrystals in the form of 3×3×0.5 mm plates were used in the experiment. The detectors were allowed to undergo thermoluminescence on a laboratory device for thermoluminescent measurements developed at the USSR Ministry of Public Health Central Scientific Research Roentgen-Radiological Institute (2). The mean square error of the relative dose measurement by the single LiF detector was 4-5 percent, and the mean square error of relative dose measurement by the single CaF_2 detector was 5-7 percent. The detectors were irradiated by standard sources of roentgen radiation and standard radioisotope sources in the ionizing radiation department of the All-Union Scientific Research Institute of Metrology imeni D. I. Mendeleyev. The "effective" energy of the roentgen radiation sources was determined on the basis of the SPO [absorption spectrum ?] in accordance with a technique described in the EULEP Protocol. The table below shows the operating modes of the roentgen apparatus in which the detectors were irradiated.

Operating Modes of Roentgen Apparatus During Irradiation of Thermoluminescent Detectors

(1) Эффективная энергия излучения, кэВ	(2) Напряжение на трубке, кВ	(3) Фильтр
36	120	(4) Без фильтра
48	120	3 мм Al
57	170	3 мм Al
72	150	0,5 мм Cu +1 мм Al
87	170	0,8 мм Cu +1 мм Al
112	200	2 мм Cu +1 мм Al

Key:
1. Effective radiation energy, kev
2. Tube voltage, kv
3. Filter
4. Without filter

The monochromatic isotope source selected was ^{241}Am (the radiation intensity at E_γ=59.5 kev is 35.3 percent in the overall spectrum of α- and γ-radiation the intensity of the rest of the energy lines in the γ-radiation spectrum does not exceed 1 percent). The detectors were not irradiated by other monochromatic radioisotope sources because the experimental result of calibrating the LiF and CaF_2 detectors in relation energetic sensitivity to the dose of the ^{241}Am radioisotope source (59.5 kev) at an error satisfying us (±5 percent) corresponded to the computed values of the energetic sensitivity of these detectors cited in the monograph by M. Frank and V. Shtol'ts (5) for monochromatic radiation at E=59.5 kev. Thus we had no grounds for suggesting that a large deviation of the experimental values of the energetic sensitivity of our detectors from values at other energy levels would be possible.

The results of our experimental determination of the energetic sensitivity of the LiF and CaF_2 detectors are shown in the figure below. The abscissa shows energetic sensitivity in relation to dose, $I(E_i)/I(E^{60}Co)$, expressing the ratio of the intensity of our detector's luminescence when exposed to radiation with energy E_i and E=1.25 Mev (^{60}Co) at an identical exposure dose. The graphs show the confidence intervals for the experimental values of $I(E_i)/I(E^{60}Co)$ used to plot the calibration curves. Because the dose measurements made by the thermoluminescent detectors are static, at the corresponding radiation energy levels the $I(E_i)/I(E^{60}Co)$ values could be averaged, and the averaged experimental points could be used directly to plot the calibration curves.

Results and Discussion

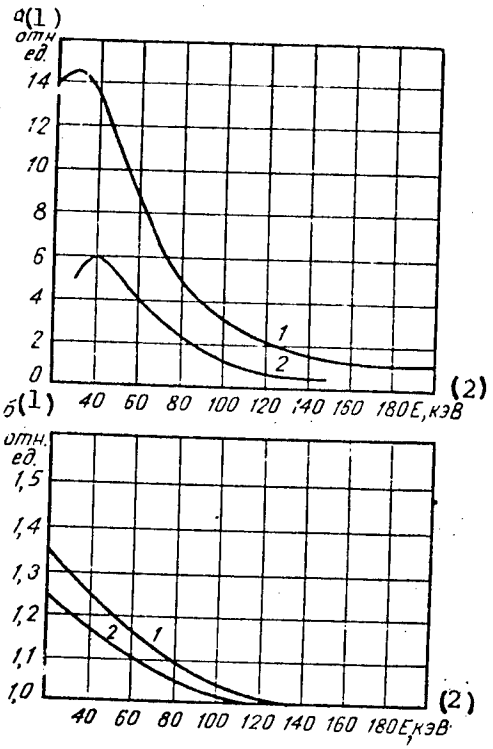
The concept of "effective" energy is in a certain way ambiguous.

In practice, "effective" energy is defined as energy corresponding to monochromatic radiation characterized by penetrability in the medium under examination equal to the penetrabilities of the radiation described having a complex spectral composition. In this case "effective" energy is determined from the effective mass coefficient of absorption of the described radiation when it passes through the medium under examination:

$$\bar{\mu} = \frac{\int_0^{E_{rp}} \mu(E)\, EN(E)\, dE}{\int_0^{E_{rp}} EN(E)\, dE}, \qquad (1)$$

where $\mu(E)$ is the mass coefficient of absorption, in the medium under examination, of radiation with energy E.

The value of the "effective" energy of the radiation spectrum depends on the material selected as the irradiated medium. This is why in our experiment the energetic sensitivity, in relation to the dose of the LiF and CaF_2 detectors exposed to monochromatic radiation, differs significantly



Energetic sensitivity of CaF_2 and LiF detectors (*a* and *b* respectively) in relation to dose: *1*--calibration for monochromatic radiation; *2*--calibration for roentgen radiation having a complex spectrum, characterized as "effective" energy."

Key:

1. Relative units
2. Kev

from energetic sensitivity for the case of roentgen radiation having a complex spectral composition, the "effective" energy of which was determined from the SPO of copper and aluminium. Moreover when we determine "effective" energy on the basis of the readings of two detectors we cannot determine the particular medium to which the "effective" energy corresponds.

In order to avoid error in determining the absorbed dose resulting from ambiguity of the assessment of the "effective" energy radiation spectrum (when the radiation spectrum has a significant influence on the size of the absorbed dose), it would be suitable to use experimental data to arrive at an approximate determination of the radiation spectrum.

The general principle of approximating a radiation spectrum by several energy lines on the basis of experimental data has been presented in the works of a large number of authors (1,3,4,7).

Actual use of the method for approximately determining the radiation spectrum with thermoluminescent detectors will be examined below.

Assume that the spectrum of roentgen radiation $N(E)$ consists of only three energy levels E_1, E_2, E_3 with weighted contributions g_1, g_2, and g_3 to the spectrum $N(E)$ by each energy level respectively. Let $I_1[N(E)]$ be the intensity of luminescence of the first detector when exposed to a 100 r dose of roentgen radiation with spectrum $N(E)$, let $I_2[N(E)]$ be the intensity of luminescence of the second detector when exposed to a 100 r dose of roentgen radiation with spectrum $N(E)$, let $I_1(E_1)$ be the intensity of luminescence of the first detector when exposed to a 100 r dose of roentgen radiation with energy E_i (i=1, 2, 3), and let $I_2(E_i)$ be the intensity of luminescence of the second detector when exposed to a 100 r dose of roentgen radiation with energy E_i (i=1, 2, 3).

Then we can set up the following system of linear equations in relation to coefficients g_i (i=1, 2, 3):

$$\begin{gathered} I_1[N(E)] = g_1 I_1(E_1) + g_2 I_1(E_2) + g_3 I_1(E_3) \\ I_2[N(E)] = g_1 I_2(E_1) + g_2 I_2(E_2) + g_3 I_2(E_3) \\ g_1 + g_2 + g_3 = 1. \end{gathered}$$

To solve equation system (2), we must determine $I_1(E_i)$ and $I_2(E_i)$ (for the LiF and CaF_2 detectors--see figure a, b) using the calibration curve for energetic sensitivity of the detectors in relation to monochromatic radiation.

Conclusions

1. When two thermoluminescent detectors with different sensitivities to linear energy loss are available, the roentgen radiation spectrum can be approximated by three energy lines.

2. As was noted by Greening, it would not be suitable to approximate the spectrum with experimental data of more than three lines, since determination of a large number of energy lines entails an increase in experimental error, and thus higher precision of spectrum assessment is not attained.

In conclusion, through the journal's editorial board the author would like to express his gratefulness to V. I. Fomin and L. V. Murzakova, colleagues of the All-Union Scientific Research Institute of Metrology imeni D. I. Mendeleyev, for their assistance in performimg the detector irradiation experiments.

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DEPENDENCE OF THE REACTION OF THE HUMAN NERVOUS SYSTEM ON THE DISTRIBUTION OF ABSORBED DOSES OF IONIZING RADIATION

Moscow MEDITSINSKAYA RADIOLOGIYA in Russian No 5, 1978 pp 3-8

[Article by G. I. Kirsanova, USSR Academy of Medical Sciences Scientific Research Institute of Labor Hygiene and Occupational Diseases]

[Text] The nervous system was found to react in unique ways in observations of large occupational groups working in the presence of chronic radiation and characterized by different distributions of absorbed energy in the human body. Concrete cases of acute radiation exposure are used to demonstrate the typical clinical manefestations of affliction of the nervous system depending on distribution of absorbed energy in brain tissues.

Research conducted in recent years (7,9,10,etc.) has shown that attempts at comparing biological impact only with the average absorbed dose lead to mistakes, especially when the action of the radiation is coupled with highly irregular distribution of absorbed energy.

The degree of nonuniformity of irradiation has an effect on responses to acute and chronic exposure. Differences in the reactions depend on radiation characteristics such as penetrability, the linear energy loss, predominant localization, and the dimensions of the radiation fields.

I analyzed the materials from clinical and physiological observations of a number of occupational groups (a total of about 5,000 persons), subjected to chronic radiation exposure at work, with a consideration for differences in the nature and cumulative radiation doses in comparison with adequate control groups.

The research shows (see Table) that given relatively uniform distribution of the dose on the surface and within the volume of the body (reactor and accelerator workers), changes arise in reflex regulation of the nervous and cardiovascular systems extremely early, in a range of moderate cumulative doses of 15-100 rems. The clinical manifestations of typical syndromes are described in publications (8-10).

At 15-30 rad doses nervous and vascular dysfunction is encountered in the main and control groups at almost the same frequency (15 and 9 percent respectively); as the cumulative dose increases and approaches 70 rems, dysfunction is encountered significantly more frequently (21-31 percent) than in control. This is more typical of persons servicing accelerators, and less typical of medical radiologists and industrial radiographers, who experience highly penetrable radiation, but extremely nonuniformly on different body areas (9,10). The frequency of this syndrome among radiologists experiencing a cumulative dose of up to 70 rad is just a little higher (16 percent) than in the adequate control group (13 percent), which can be explained by significant nonuniformity in distribution of the dose on the surface and within the body. Not being a manifestation of chronic radiation sickness, the extended autonomic-vascular lability syndrome is essentially adaptive, having no affect on the way the individual feels and his working ability and manifesting itself only through special research methods (2).

As the cumulative doses increase to 150 rems and more, the hypotonic neurocirculatory dystonia syndrome becomes typical, together with change in regional hemodynamics in the skin, limbs, and the brain. In addition to lability of pulse and arterial pressure, instability of vascular tone in different areas, particularly cerebral, is noted, usually as a decline. First the tone of the arteries declines, and then of the veins, which is confirmed by rheographic data, calibrometry of vessels in the ocular fundus, and capillaroscopy. Blood supply to neurons in the brain does not suffer significantly, which is confirmed by absence of the corresponding clinical neurological symptoms and by normal bioelectric activity of the cerebral cortex. When other typical manifestations develop (change in blood, marrow hemopoiesis, and so on), hypotonic neurocirculatory dystonia transforms into the chronic radiation sickness syndrome. Such changes were observed more frequently in the group of persons working with permanent fluorescent substances and industrial radiographers.

At cumulative doses of more than 150 rems some persons develop the asthenic syndrome, which is the next stage in nervous system problems, characterized by exhaustion of the the functional capabilities of a number of systems and of the regulatory mechanisms. Arterial hypotension of greater stability develops, and monotony of and a decline in reactivity of all autonomic indices and heightened exhaustion of motor neurons are noted, expressed as a significant decline in the amplitude of bioelectric oscillations on the EMG. The decline in functional capabilities of higher centers of the central nervous system manifests itself as higher mental tiring, a decrease in attention, memory, and efficiency, and disturbance of the interaction of analyzers.

The asthenic syndrome was diagnosed among 17 percent of the medical roentgenologists who had worked more than 20 years with poorly shielded apparatus (the average doses were about 400 rems). This group was also the oldest, which could also have an effect on the frequency of asthenia. However, in an adequate control group consisting of people over 40 years old the asthenic syndrome was noted among only 4 percent of them.

Dependence of the Frequency of the Neurovascular Syndrome on Cumulative Dose (Overall and Local), Types of Radiation, and Distribution of the Dose in Individual Body Areas.

Occupational Group	Number Examined	Radiation Types	Irradiation Uniformity	General Reactions		Local Reactions	
				Cumulative Average Dose, Rems	Frequency, %	Cumulative Local Dose, *Rems	Frequency, %
Persons servicing reactors	1027	γ-radiation, neutrons	uniform	< 25	15	25	15
Accelerator workers	800	γ-radiation, neutrons	as above	≃ 30-100	31	> 30	31
Industrial radiographers	400	γ-radiation, roentgen radiation	nonuniform (mostly the hands)	≃ 70	27	1000	41
Medical radiologists	400	β- and γ-radiation	as above	≃ 100	24	1000-5000	64
Medical roentgenologists	1000	Roentgen radiation	nonuniform (mostly the skin of the hands)	> 150	23	1000-3000	69
Persons working with permanent fluorescent substances	150	γ-, β-, and α- radiation	nonuniform among body areas	> 150	37	> 1000	60
Persons working with isotopes in scientific research institutions	1000	γ-, β-, and α- radiation	nonuniform (mostly the hands)	≃ 100	30	no information	-

* The local dose is given for the body area experiencing maximum irradiation.

On the whole the asthenic syndrome is observed no more frequently among persons working with radium compounds than people in the adequate control group (10 and 7 percent respectively), and it was diagnosed among all persons with a cumulative dose greater than 150 rems. In this case it was combined with other signs of radiation effects (change in the hemopoietic system and respiratory organs). It should be emphasized that persons working with radium compounds exhibit a complex system of radiation symptoms; external nonuniform γ-radiation makes the main contribution to the dose (up to 80 percent), and at a later time the action of the isotope manifests itself together with selective deposition in bones and respiratory organs. This combined action causes changes in a large number of organs and systems, which can in turn be the cause of the significant stability of the asthenic syndrome.

The dependence of the body's reactions to adequate cumulative doses of different types of ionizing radiation can also be demonstrated in the reaction of the neurovascular apparatus of skin on the hands.

Thus it was noted in a comparision of changes in skin pain reception, capillary blood flow, and some local autonomic indices (12) that among persons exposed to uniform highly penetrable gamma- and neutron radiation, these indices change rather early, at a dose of up to 100 rems, which was not noted among persons experiencing irradiation of the hands predominantly (medical roentgenologists and medical radiologists making manipulations with their hands). This can apparently be explained by the fact that in the group of persons experiencing uniform general radiation, changes in the peripheral neurovascular apparatus are an inherent part of general regulatory changes, and not the result of local exposure. If reactions are to be revealed in response to predominantly local exposure of the hands to relatively soft roentgen radiation, the doses must be significantly greater, on the order of hundreds and even thousands of rads. This produces a unique dissociation between local and general phenomena in this category of workers. Thus chronic radiation injury of the skin of the hands was diagnosed without signs of general body reactions for eight (2 percent) out of 360 physician-roentgenologists who had worked for a long period of time. At the same time change in pain reception of the skin of the hands and disturbance of peripheral capillary circulation without phenomena of radiation injury of the skin were diagnosed among 66 percent of physician-roentgenologists receiving a general cumulative dose greater than 150 rems and among 30 percent of gynocological radiologists and nurses, the hands of whom received cumulative doses in excess of 1000 rems.

The specific way in which radiation is distributed within the irradiated volume has an effect on the nature of the nervous system's reflex responses and, in the presence of acute irradiation, mainly on the times of their arisal and their expressiveness.

We know that the expressiveness and time of arisal of the initial reaction in cases of acute radiation sickness can serve as the criterion of the

overall severity and the prognosis of the disease. However, this is valid only when the nonuniformity of energy distribution is accounted for. In addition to the dimensions of the radiation fields, the unique features of nervous formations within the zone of maximum irradiation have significance. Comparable cases include I and III, and II and IV. The expressiveness of the initial reaction depends basically on the radiation dose experienced by highly reflexogenic zones such as the head, neck, and chest; the greater the severity of illness in each of its periods, the more highly pronounced are the secondary changes exhibited by the nervous system.

The specific way in which the energy of ionizing radiation distributes itself in space also exhibits itself in data of electrophysiological rerearch on patients suffering acute radiation sickness (13; A. K. Gus'kova, 1955, 1961, 1971). The nature and time of revelation of changes in brain bioelectric activity (from EEG data) in people subjected to one-time general or local (the head) irradiation vary in this case in relation to the principal physiological mechanisms. In the case of general irradiation, the cortical reaction is governed by a powerful flux of pathological impulsation from the irradiated periphery, which is clearly detected at an early time and which attenuates with time. Irradiation of the head, meanwhile, (of course at higher doses) produces less-pronounced general reactions, later leading to relatively stable, gradually progressing disturbances of brain bioelectric activity (in connection with developing organic lesions of brain tissue).

The volume and uniformity of nervous tissue irradiation acquire even greater significance (depending on the radiation energy) to establishing the nature and depth of the injurious action of radiation upon nervous tissue. This can be seen both in observations of people who had experienced acute radiation sickness (8; I. S. Glazunov et al.), and from an analysis of some complications of radiation therapy. We know that the brain's tolerance to irradiation depends on the volume of tissues irradiated; the greater the volume, the greater the injury, and vice versa (4,6,11, etc.). Given sensible therapeutic irradiation the volume of healthy tissues exposed decreases significantly, and owing to this the percentage of complications, including serious ones such as brain necrosis, decreases. Sensible procedures can include irradiation through a screen, implantation of point radiation sources, use of β-radiation taking the form of narrow beams of high-energy particles (B. M. Aliev and A. K. Gus'kova; F. M. Lyass; etc.)

Thes premises can be illustrated by two concrete examples from my observations.

Observation I: Irradiation (occurred due to the victim's carelessness) by a 50 Mev beam from a linear accelerator, located in the vicinity of the right temple and right forehead. According to the initial dosimetric data sheet the irradiation dose did not exceed 100 rads, with the contribution of fast and intermediate neutrons with a high penetrability being significant. However, depilation developing in the third week in the region of the forehead and temple, and hyperemia of the skin transforming at the end of the 4th week

into hyperpigmentation, indicated that the doses were larger, attaining a minimum of 500-600 rads on the skin.

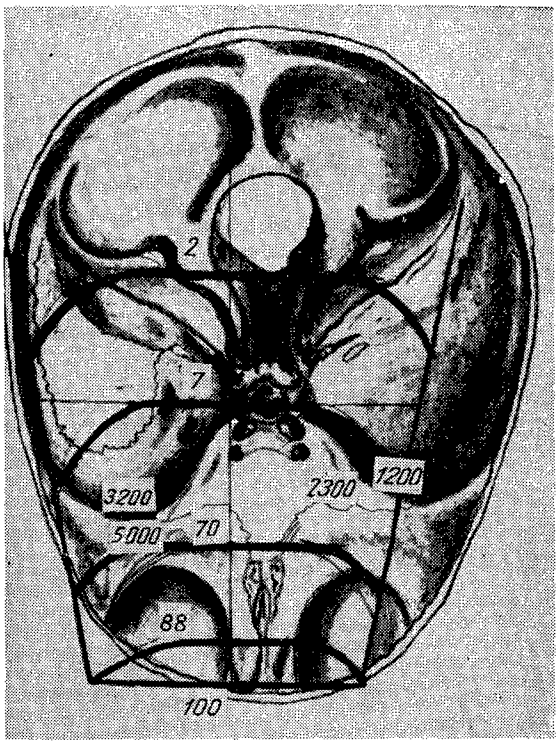
Between the 20th and the 35th-38th days the patient complained almost constantly of headaches. Except for a certain autonomic instability typical of the patient prior to irradiation, no changes were noted in neurological status. Electroencephalographic analysis on the 35th and 42d days revealed changes in the anterior divisions of the brain on the right -- taking the form of a certain reduction in the α-rhythm, and in profound structures on the left -- appearing as pathological forms of impulsation in response to hyperventilation. In this case the latter changes were more stable. On the 56th day no changes were noted on the EEG. The transitory nature of changes in brain electric activity and the fact that the brain divisions that were in a sense "along the path" of the beam were responsible for these changes encouraged the suspicion that they were related to the radiation effect, and the hypothesis that certain divisions of the brain had been subjected to neutron irradiation at doses of about 600 rads (if it is assumed that the proportion of neutron irradiation exceeded the proportion of the softer components). An examination 2 years later revealed symptoms of mild left-sided pyramidal insufficiency, confirmed electromyographically, in the absence of EEG changes.

Observation II: A patient whose head (on the right for the most part) was exposed to a localized beam of roentgen radiation at an exposure dose of 10,000 rads was kept under observation for 7 years. Information on the patient covering the first years was cited by A. K. Gus'kova, G. D. Baysogolov, A. V. Barabanova et al. in 1971 and 1972, and the outcome was described by D. A. Ulitovskiy et al. in 1975.

The distribution of absorbed energy is shown in L. V. Novikova's figure below.

The expressiveness of the initial reaction was significant, which can be explained by irradiation of areas of the face richly supplied with receptor formations and the brain itself by a tremendous dose. In the acute period of disease, at the climax of skin lesions and lesions of the mucous membranes and eyes, changes in the nervous system did not exhibit distinct focal signs. Later, in the 2d-3d years of observation, a gradual increase of autonomic and vascular insufficiency was noted, stemming from disturbances of circulatory regulation of central origin, which in turn led to disturbances in blood and liquor dynamics of the brain. Vascular crises coupled with heightened arterial and intracranial pressure began to play a major role in the clinical pattern.

Disturbances in blood and liquor dynamics at the times of crisis were typified by worsening of overall conditions, attacks of severe headaches, and insomnia; the patient became withdrawn, gloomy, and irritable, and his arterial pressure gradually increased to 160/100-170/110 mm Hg. The patient exhibited hypokinesia, a shaky gait, instability in the Romberg



Distribution of Absorbed Energy

position, and misses and intensity during performance of cordination tests with the left hand. Muscle tone was low on the left, tendon reflexes were higher on the left and coupled with a clonic element, especially in relation to the knee jerk reflex and even more so the Acchiles tendon, and pathological symptoms (Rossolimo, Babinski) were now and then observed on the left.

A decline in the overall brain blood supply was noted, earlier due to spasms of the arteries and later in the form of venous hypotension; signs of liquor hypertension were observed as well. Interhemispheric asymmetry revealed itself later. Brain bioelectric activity was significantly altered: The α-rhythm was reduced to the point of its total disappearance, and pathological rhythms began to arise in the terminal period even on the background EEG.

Therapeutic measures improved the patient's condition, the neurological symptoms were alleviated somewhat, and a variable tendency toward normalization of the EEG was observed.

In the 6th-7th years the signs of functional disturbances diminished somewhat. But phenomena of regional circulatory insufficiency and symptoms of ogranic brain lesions began to play the dominant role in the neurological manifestations of disease.

Atrophy of the left optic nerve, which began to manifest itself in the 7th year of illness as constriction of the field of vision and temporal hemianopsia, progressed. The symptoms of pyramidal insufficiency and the signs of organic lesions of the frontal lobes coupled with typical mental changes began to be stable.

In the final period of observation the symptoms of injury to cranial bones dominated the clinical pattern: Radiation osteonecrosis, osteomyelitis coupled with recurring septic complications taking the form of facial phlegmon, formation of fistulas, and recurrent nosebleeds.

Tha patient died 7.5 years after irradiation. The direct cause of death was purulent meningoencephalitis which had developed as a complication of osteomyelitis of cranial bones.

These observations emphasize the need for deeply studying the role of spatial and temporal relationships in radiation neurology and radiation therapy. Such study would permit us to assess, with better grounds, the diagnostic and prognostic significance of neurological symptoms, which is important to both an understanding of the general laws governing reactions to irradiation and understanding the uniqueness of each individual observation.

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ALL-UNION CONFERENCE ON TRANSFER PROCESSES IN BIOLOGICAL SYSTEMS HELD

Moscow ZHURNAL OBSHCHEY BIOLOGII in Russian No 3, 1978 pp 478-480

[Conference report by G. V. Dontsova, Ye. V. Presnov and V. A. Grudnitskiy on the All-Union Conference "Kinetics and Thermodynamics of Transfer Processes in Biological Systems"]

[Text] The Institute for the Biology of Development imeni N. K. Kol'tsov of the USSR Academy of Sciences on 12-14 September 1977 held a conference on "Kinetics and Thermodynamics of Transfer Processes in Biological Systems." Participating in the conference were 108 specialists from six Union republics representing 22 cities, 56 scientific research institutes and 9 departments. The percentage of persons attending the conference was: 45 percent physicists, 30 percent biologists, 9 percent mathematicians and 8 percent chemists. The first day of the conference's work was devoted to a discussion of the problems of the thermodynamics of nonlinear irreversible processes, the second day to the kinetics and thermodynamics of transfer processes, and the third day to transfer processes in biological systems. The papers were largely with exhibits. Their demonstration was accompanied by lively debates and this, in the words of the conference participants, was interesting and useful.

The Problems of the Thermodynamics of Nonequilibrium Processes

The conference was opened by a paper of F. M. Kun', L. Ts. Adzhemyan, A. P. Grinin, T. Yu. Novozhilova and B. A. Storonkin "Statistical Thermodynamics of Nonlinear Irreversible Processes" (Leningrad). The paper analyzed the problem of statistical thermodynamics and described the basic areas and methods of statistical theory.

The paper of Ye. V. Presnov "Phenomenological Equations and Criteria for Nonequilibrium Thermodynamics" (Krasnoyarsk) investigated the structure of nonlinear thermodynamic flows; a thermodynamic interpretation was given of the Hamilton equations; the question was discussed of constructing a thermodynamic criterion for the evolution of biological systems.

The paper of A. B. Rubin "Thermodynamics and Biology" (Moscow) was devoted to a review of the work of the Biophysics Chair of Moscow State University

on the problems of biosynthesis, electron transport, fermentative catalysis and biological membranes.

The exhibit statements of A. I. Zotin and R. S. Zotina "Criterion for the Evolution of Systems Far from Equilibrium" and "Kinetics for Approximating an Open System to a Stationary State" (Moscow) offered an analytical expression for breaking down the functions of external dissipation. A statistical interpretation was examined for dissipative functions and a mathematical theory was elaborated for the time conduct of these functions.

The statement of L. S. Kotousov "The Rise of Heterogeneous Bodies in the Fields of Their Interaction" (Leningrad) dealt with the problems of the rise of a temperature-heterogeneous system in an external field. L. S. Kotousov and G. Chanieu (Paris) in "The Use of the Method of Nonequilibrium Thermodynamics for Calculating the Coefficients for the Activeness of Components in Binary Mixes" gave a new method for calculating the concentration derivatives from redundant potentials in a quasilinear area.

A. A. Platonov in the statement "The Possibilities of a Thermodynamic Approach to an Analysis of the Statistical Properties of Nonlinear Dynamic Systems" (Moscow) examined the analogy between the problems of nonequilibrium thermodynamics and the statistical theory of dynamic systems.

Kinetics and Thermodynamics of Transfer Processes

D. N. Zubarev gave the paper "A Generalized Fokker-Planck Equation in the Theory of Nonequilibrium Fluctuations" (Moscow). The Fokker-Planck equation plays one of the central roles in the statistical theory of irreversible processes. The intensive study of this equation entails the problems of establishing the bases of statistical mechanics.

The paper of V. A. Vasil'yev and Yu. M. Romanovskiy "Stable Orbitals and Transfer Processes in Models of Biological Systems" (Moscow) touched upon an important area in biological thermodynamics, the theory of dissipative structures.

A paper "The Kinetics of Chain (Conjugate) Biophysical-Chemical Processes" was tiven by S. S. Vasil'yev (Moscow). It was devoted to a review of special questions of the kinetics of nonequilibrium processes using the methods of the linear theory of differential equations.

A. M. Molchanov (Pushchino) offered the paper "The Ideas of Khinchin in the Kinetics of Large Systems" and in which he described the methods elaborated by the Soviet mathematician Khinchin on the problem of establishing statistical thermodynamics; these methods had been forgotten and are now being developed by Molchanov.

In an exhibit statement of N. M. Yeremeyeva and N. V. Stepanova "Immune Reactions as a Stationary State of an Organism" (Moscow), the immune response of an organism to an external effect, the antigen, was examined.

The statements of E. Z. Rabinovich "An Examination of Transfer Processes in the System of Blood Circulation Within the Framework of the Theory of Dynamic Systems" and "Thermodynamic Criterion of Optimality for the Controlling Function of a Dynamic System With Transfer Processes in the Organism" were devoted to a qualitative analysis of transfer processes. The conclusion was drawn on the possible existence of a principle of a reaction of a living system to an effect.

The statement of L. N. Ter-Ovanesyan "Comparison of a Functional in the Theory of Optimal Control and Dissipative Function" (Moscow) dealt with the question of constructing a functional possessing the properties of a dissipative function for irreversible processes occurring in open systems.

N. V. Fentsov, V. A. Vasil'yev, L. L. Litinskaya and Yu. M. Romanovskiy in the statement "Multichamber Self-Oscillating Models of Biological Systems with Nonspecific Inhibiting of Active Transport" (Moscow) stated that in localizing the diaphragm pumps of organellas in a cell [sic.], any number of one type of organellas will work synchronously.

Transfer Processes in Biological Systems (Experimental Analysis)

The paper of I. A. Arshavskiy and E. Z. Rabinovich "Specific Features of Thermodynamics in Transfer Processes in the Individual Development of Mammals" (Moscow) gave in detail notions of differences in transfer processes in living and nonliving open systems.

V. V. Khaskin in the paper "Energy Value of Homeostasis and Its Changes in the Adaptation of Animals" (Novosibirsk) pointed out that an adaptive rise in the energy effectiveness of reactions is combined with a rise in the overall physiological effectiveness of energy expenditures.

The paper of M. A. Khanin and I. B. Bukharov "Extremal Principles in Physiology" provided a review of works on the use of extremal principles in physiology and biochemistry.

V. A. Grudnitskiy in the paper "Change in Energy Metabolism of Animals with an External Effect" (Moscow) showed that changes occurring on the level of energy metabolism represent a nonspecific response of the organism to the action of the most diverse factors.

In the exhibit statement of I. A. Arshavskiy, T. A. Bal'magiya, V. A. Yelin, and V. D. Rozanova "Transfer Processes in the Individual Development of Mammals and the Mechanisms of Gerontogenesis" (Moscow), the authors concluded that aging occurs as a consequence of sclerotic changes in the blood vessel system.

The statement of I. S. Breslav, G. G. Isayev and A. M. Sheleva "Analysis of the Regulation of Breathing in Man During Transitional and Stable Periods of Muscular Activity" (Leningrad) pointed out that during work the regulation of breathing is carried out by a purely nervous regulating mechanism.

T. N. Vorob'yeva, N. F. Pyt'yeva and A. B. Rubin in the statement "Thermodynamic Characteristics of Electron Transport Processes in Photosynthesizing Bacteria" (Moscow) examined the kinetics of photoinduced oxidation of chromatophore pigment in bacteria.

In the statement "Dynamic Characteristics of Heat and Moisture Exchange of the Human Organism," A. A. Glushko (Moscow) gave the results of studying transfer heat states in the organism using the methods of biothermometry, biohygrometry and biocalorimetry.

S. A. Musyashchikova, M. S. Sinyaya and A. A. Morkushin in the statement "Research on Transfer Processes in the Visceral Analyzer" (Leningrad) took up the dynamics of induced potentials and the pulse activity of neurons. The statement "Kinetics of Biological Transport of Electrons in the Process of Photosynthesis" was given by G. Yu. Riznichenko, S. K. Chamorovskiy, V. N. Shinkarev, T. N. Vorob'yeva, A. I. Ratyni, N. F. Pyt'yeva and A. B. Rubin (Moscow). The authors disclosed the mechanism for regulating the processes of electron transport with a change in the external environmental conditions. S. A. Konovalov and V. V. Koryagin (Moscow) in the statement "On the Question of Kinetics and Thermodynamics of Transfer Processes in Microorganisms" noted the kinetic and thermodynamic features of transfer processes. The following statements were also given: S. G. Galaktionov and V. M. Yurin "Temperature Dependence of the Processes of Ion Diffusion Through the Membranes of Plant Cells" (Minsk); N. N. Kolotilov and E. A. Bakay "The Effect of the 'Memory' of the Liquid Crystalline Structures of the Axon Membrane--A Possible Mechanism of the Refractor Period" (Kiev); D. M. Seksenbayev and I. Yu. Tashmatov "Characteristics of Electric Parameters of Human Skin in Adaptation to Alpine Conditions" (Frunze); A. I. Chuchalin, F. Ya. Sid'ko, G. M. Lisovskiy and V. I. Polonskiy "Transfer Processes of CO_2 Gas Exchange in Wheat Cenoses in Changing the Radiation Level" (Krasnoyarsk); V. I. Fedorov "Dynamics of Structural Transformations in Physiological Systems with Loads of Varying Intensity and Duration" (Novosibirsk); G. V. Dontsova, I. G. Vladimirova and V. A. Grudnitskiy "The Effect of Consuming Food After Extended Starvation on the Energy Metabolism in Planaria" (Moscow).

Transfer Processes in Biological Systems (Mathematical Modeling)

The following papers were submitted on this section: G. K. Abasheva, L. M. Mikhneva and L. B. Stanishevskaya "Mathematical Model of the Dynamics of Corticosterone With a Pulse Effect of ACTH" (Minsk); N. N. Gavrilov, V. I. Timonin and V. N. Fedyunin "On Certain Probability Aspects in the Development of Organisms" (Moscow); V. Ya. Gel'man, A. D. Dolgushina, G. N. Il'yutkin, Ye. V. Maystrakh and V. I. Tarabukin "Mathematical Modeling of Transfer Processes in Arterial Pressure With the Effect of Vasoactive Substances" (Leningrad); S. L. Zaguskin and S. N. Grinchenko "Energy Characteristics of the Adaptation of a Nerve Cell" (Rostov-na-Donu); V. L. Kaler and L. Ye. Fridlyand "Kinetics of Transfer Processes in the Adaptation of the Photosynthetic Apparatus of Plants to Environmental Conditions"

(Minsk); G. E. Insarov "Stationary Distribution of the Adaptation Level of Populations" (Moscow); S. M. Semenov "Transfer Processes and Stationary States in the Movement of the Size of Populations" (Moscow); L. I. Lishchitovich and A. B. Khatset "On Modeling Critical Periods of Plant Ontogenesis as Transfer Processes in an Organism" (Kiev); V. G. Yakhno "Nonstationary Wave Movements in Distributed Biological Systems" (Gor'kiy); Yu. M. Romanovskiy, N. K. Tikhomirova and Yu. I. Khurgin "An Electromechanical Model of an Enzyme" (Moscow); M. I. Shterenberg "On Structural Questions of Biological Thermodynamics" (Moscow). The conference demonstrated the interaction of the ideas and methods of biology, physics, chemistry and mathematics. However, this area of science is still in the beginning of its development. Such a situation determined the thematic diversity of the papers submitted from the purely mathematical to the biological.

10272
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FIRST ALL-UNION CONFERENCE ON BIODAMAGE MEETS

Moscow ZHURNAL OBSHCHEY BIOLOGII in Russian No 3, 1978 pp 476-478

[Conference report by Ye. V. Titova on the First All-Union Conference on Biodamage]

[Text] The First All-Union Conference on Biodamage organized by the Scientific Council of the USSR Academy of Sciences on Biodamage (V. D. Il'ichev, chairman) was held in Moscow on 24-27 January 1978.

Participating in the work of the conference were over 300 specialists from various areas including microbiologists, physiologists, biochemists, hydrobiologists, zoologists, chemists, production engineers, engineers, construction workers, representing around 100 institutions of the USSR Academy of Sciences, the Union republic academies of sciences, the Gosstroy, the USSR and RSFSR Minvuz [Ministry of Higher and Specialized Secondary Education], and the ministries of the aviation, automotive, woodworking, lumber, light, medical, petrochemical, petroleum and gas, shipbuilding, chemical, pulp-paper, electronic, and electrochemical industries, the ministries of public health, culture, reclamation, water management, communications, metallurgy and other departments.

At the plenary sessions and the sessions of the five sections, 129 scientific papers were presented.

The conference was opened by the chairman of the Scientific Council on Biodamage, V. D. Il'ichev. In his report he pointed out that while previously man protected himself against biodamage and injury as it were passively and basically using local methods, at present this problem should be solved on the basis of ecological and technological approaches, that is, by complex and multistage approaches which provide for the consequences of the interaction of the materials with live organisms and the biosphere. The strategy for protection against biodamage also includes the development of new bioresistant materials and materials with biocide properties, the protection of materials and articles which have already been developed and are in use, and biodestruction of what has served out its life and is obsolete. With such approaches, complete and all-round knowledge is required on all aspects of the relationships of the biosphere with the materials and articles from them.

Until recently, biodamage had been detected more often specifically and sometimes accidentally, and methods of protection against this damage was basically sought for specific situations. At the same time, it is becoming all the more essential to establish the general traits among these situations and classify them according to definite features. The agents of biodamage enter into the links of biocenotic chains and, consequently, are related to them and to the damaged materials by the biocenotic ties. Proceeding from this, the problem of biodamage can be viewed as an ecological one, since it is directly related to the environment, and as a technological problem related to the creative activity of man. With such a systems approach, there is a real opportunity of forecasting the biodamage and determining a general estimate of it and the economic loss.

In the following plenary report, D. P. Zhuzhikov (Moscow State University) pointed out that as a result of theoretical interdisciplinary research in the area of biodamage, the development of a new sector of science was emerging, in studying the interaction of the organisms and materials, and the following areas of work had been defined:

1) Research on the specific composition of the organisms and the nature of their effect on the materials, articles and structures considering the economic impact;

2) A study of the physiological features, development, behavior, ecology and distribution of organisms which most actively influence the materials, articles and structures, as well as their variability and adaptability to new conditions;

3) Research on the succession of microbiocenoses which develop in the various stages of the destruction of materials as well as nearby articles and structures;

4) A study of the mechanism of action of biological factors on materials and articles;

5) An ecological-geographic study of the bioresistance of materials, articles and structures;

6) Optimization and standardization of the testing methods of materials;

7) The search for effective methods for protecting damageable materials from the effect of biodamage agents;

8) The development of materials and articles with set bioresistance property;

9) The development of methods which are safe for man and the environment for controlling the number of organisms affecting materials, articles and structures;

10) Optimization of conditions for the intensive multiplication and activation of organisms which destroy materials which have lived out their life.

Yu. P. Nyuksha reported on the development of a thorough investigation of the processes of biodamage. This has made it possible to make certain general scientific theoretical generalizations. Specific biocenotic ties are often formed in anthroprogenic media. The broadening of the ranges of certain organisms can be explained by their ecological and physiological-biochemical properties and by their broad ecological amplitude. Many industrial materials can be viewed as an ecological niche of an anthropogenic character. Biocenoses have already been determined for certain industrial materials, and the adaptability of the organisms to these substrates has been shown.

The paper of A. M. Tsukerman (Institute for the History of Natural Science and Technology Under the USSR Academy of Sciences) was devoted to the chemical aspects of the protection of materials against biodamage. The most widely spread method of protecting materials against biodamage is the chemical one using compounds that are toxic for the organisms, or employing repellents, attractants, biocides with a limited period of action and broad-spectrum biocides.

V. A. Vasnev (Institute of Organielemental Compounds of the USSR Academy of Sciences) pointed out that the use of compounds that are toxic for an organism entails the introduction of them into the environment. The use of bioresistant materials inevitably causes the accumulation of them in the biosphere. The problem of protecting materials against biodamage has a dual nature. On the one hand, materials are required which are resistant to the action of organisms, and on the other, the creation and use of such materials excludes them from the general circulation of matter in nature and leads to the pollution of the environment. The search for biological destruction methods for materials which have been used and served their life is assuming important significance, all the more as with such approaches resources can be discovered for obtaining additional valuable materials. A search is already underway for microorganisms which could be used for destroying used materials and obtaining useful products for the national economy (proteins, alcohols, fuel and so forth). Recently research has been intensified on developing and synthesizing polymers which are hydrolyzed by proteolitic enzymes. New classes of biopolymers have been obtained which are hydrolyzed by certain endopeptidases. Of great interest are the biodegradable polyamides. The use of such biodegradable plastics is very valuable from the standpoint of protecting the environment.

At the session of the Section "Microorganisms and the Lower Plants" some 55 scientific papers were given (including 29 with exhibits).

The papers presented data on the ecology, physiology and biochemistry of bacteria, fungi, actinomycetes and certain agents of biodamage, various

industrial metallic and nonmetallic materials, petroleum and oil products, optics, textiles, and paper used in various national economic sectors and under different climatic conditions; on the mechanisms of interaction of the organisms with the various classes of materials, on the specific composition of the microorganisms in various materials, their biocenotic links, successions as the materials age; on the disclosure of patterns of action of fungicides on the metabolism of microorganisms. Recommendations were given on protecting various materials used in the national economy, and for employing biocides that were safe for the environment and man. Particular attention was given to the necessity of standardizing and unifying the methods for assessing the bioresistance of materials and systematizing the terminology.

Some 23 papers were presented at the session of the Section "Fungal Damage to Wood and Other Building Materials. Methods of Protection." Wood is widely used in the national economy and is a building material unsurpassed in terms of specific strength, however it is often damaged even in the forest, in transporting, at storage areas and in structures. The submitted papers produced data on the specific composition of the wood destroying fungi, their ecology, classification, the nature of the damage to the wood, the preventive measures, the methods for saturating wood with antiseptics, and on the necessity of rapidly introducing the data of scientific research into production.

The papers provided recommendations on increasing the durability of wood parts and structures, and preserving monuments of wooden architecture.

The papers of the section "Fouling and Biocorrosion in Water" (17 papers were given) provided information on the damage caused by fouling organisms (bacteria, algae, sponges, mollusks, barnacles, ship worms and so forth) to materials, articles and structures submerged in water.

Virtually all the destructive aquatic organisms and overgrowths are mass species which perform an important role in the productivity of the biosphere in the natural and directed process of the spontaneous purification of the water, air and soil, and for this reason the protection against them requires very careful, more often local measures. The reports discussed the questions of the use of the quaternary compounds of ammonia for combating fouling in the systems of industrial water supply, protection against fouling by an anode solution of copper, protection by electrolysis chlorination, the questions of the effect of chlorine and nitrate ions on the Dreissensia [zebra mussel] which are the basic overgrowth of bodies of fresh water, and so forth.

The plenary papers examined the problems of anthroprogenic pollution and its effect on the reproduction of the invertebrate overgrowths in the littoral marine zone (S. A. Mileykovskiy, Oceanology Institute of the USSR Academy of Sciences), as well as the results of analyzing new nonfouling surfaces for fresh water (G. D. Lebedeva, Moscow State University).

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Some 14 papers were submitted to the Section "Insects and Rodents--Destroyers of Materials and Technical Devices." These gave data on the specific composition of the insects which damage industrial and museum materials, on the ecology, biology and physiology of these insects, including on the particular features of voraciousness of the clothes moth caterpillars in various populations and the importance of these data for testing materials for bioresistance, and on methods for protection against termites. The principles for protecting museum exhibits against skin beetles were formulated.

Synthetic materials which are widely used in the national economy have been an object of the gnawing and digging activities of rodents. The growth of the economic harm caused by rodents has confronted specialists with the tasks of disclosing the conditions and factors which contribute to the causing of damage, a study of the biology of harmful species, and the necessity of finding industrial materials which are resistant to damage.

Some 7 papers were submitted to the Section "Protection of Raw Products, Materials and Technical Devices Against Birds." Birds cause damage to aviation, means of transport, to the national economy, and architectural monuments, and also damage power transmission lines. Among the means for protecting technical devices against birds, ecological ones are the most effective and these include means for frightening off the birds, for scattering them and redistributing them over the territory of an airfield. The study of the ornithological situation in the areas of airfields and the forecasting of the migrating of birds are of important significance.

In summing up the results of the conference, Academician A. A. Imshenetskiy, A. A. Anisimov (Gor'kiy University), Yu. P. Nyuksha and other participants noted the great urgency and practical significance of the questions reviewed at the conference and related to protecting material resources against biodamage in the aim of raising the prosperity of the people. They noted the broad involvement of specialists working in the area of biodamage protection for the most diverse materials and articles used by various departments; they also noted the substantially increased role of the Scientific Council of the USSR Academy of Sciences on Biodamage.

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